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WM. SPRARAGEN
Editor

AMERICAN WELDING SOCIETY

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JOURNAL OF THE AMERICAN WELDING SOCIETY

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Tentative Program

FALL MEETING
of the
AMERICAN WELDING SOCIETY
SEPTEMBER 21-25, 1931
COPLEY PLAZA HOTEL, BOSTON, MASS.

IMPORTANT NOTICE

Members and guests are requested to register immediately upon arrival as admission to exposition and participation in social events and inspection trips will be by badge only.

Upon registering you will be furnished with copy of the Journal containing papers to be presented at the technical sessions. The supply of Journals is limited, one to each registrant, and on this account you are urged to retain your copy throughout the meeting.

All technical sessions and committee meetings will be held at the COPLEY PLAZA HOTEL.

All sessions will start promptly as scheduled.

Monday, September 21st

Morning

REGISTRATION

9:45 A.M., Facilities will be provided throughout the week from 9:30 A.M. to 5:00 P.M. commencing Monday, September 21st at 9:45 A.M.

Afternoon

TECHNICAL SESSION

3:00 P.M., Presiding Officer—L. S. Moisseiff, Chairman, Structural Steel Welding Committee.

A review of the work of this committee, the investigations undertaken by it and the results of tests of 1395 specimens made up by 39 fabricating shops and tested at 24 laboratories will be presented by the Executive Committee of the Structural Steel Welding Committee.

Evening

6:30 P.M., Dinner Meeting, Board of Directors Copley Plaza Hotel. Presiding Officer—E. A. Doyle, President, American Welding Society.

Tuesday, September 22nd

Morning

BUSINESS SESSION

9:45 A.M., Presiding Officer—E. A Doyle,. President, American Welding Society.

This will be in the nature of a few introductory remarks by President Doyle; address of welcome by Hon. Mayor James M. Curley, response by C. A. McCune, Chairman, 1931 Fall Meeting and Exposition Committee, and transactions of formal business.

TECHNICAL SESSION

10:15 A.M., Presiding Officer—E. A. Doyle, President, American Welding Society.

The Yale University Group of Welded Buildings, by G. D. Fish, Consulting Engineer.

Welding Solves Another Problem, by F. P. McKibben, Consulting Engineer.

Automatic Gas Cutting, by R. F. Helmkamp, Air Reduction Sales Co.

Afternoon

OUTING

3:00 P.M., Trip to Pemberton by boat.

Shore dinner and sports, returning in evening for moonlight sail. Transportation from hotel to pier by buses, leaving hotel promptly at 3:00 P.M.—Price $2.00 per person.

Wednesday, September 23rd

Morning

TECHNICAL SESSION

9:45 A.M., Presiding Officer—H. P. Peabody, Chairman, Boston Section, American Welding Society.

The Future of Welded Ship Construction, by J. Kjekstad, United Dry Docks, Incorporated.

Resistance Welding of Metal Fabric, by W. T. Ober, Thomson Gibb Electric Welding Co.

Four Problems Encountered in Flash-Welding Mild Steel, by E. R. Torgler, S. R. Dresser Manufacturing Co.

Afternoon

TECHNICAL SESSION

2:00 P.M., Presiding Officer—C. A. McCune, Past President, American Welding Society.

The Engineer, The Welder and The Foundryman, by P. J. Horgan, Lynn Works, General Electric Company.

Maximum Stress—Its Influence on Cost and Service Life of a Structure, by Everett Chapman, Lukenweld, Inc.

Welding of Galvanized Steel, by H. F. Reinhard, J. B. Colt Company.

Fatigue Properties of Welds, by R. A. Weinman, General Electric Company.

Thursday, September 24th

Morning

TECHNICAL SESSION

9:45 A.M., Presiding Officer—J. J. Crowe, member of Executive Committee, American Welding Society.

The Relief of Welding Strains by Annealing, by C. H. Jennings, Westinghouse Electric & Mfg. Co.

Welded Pipings and Fittings in Heating Installations, by F. J. Maeurer, Air Reduction Sales Company

Welding of Copper and Brass Piping, by H. V. Inskeep, Development Section, Engineering Dept., Linde Air Products Co.

Afternoon

TECHNICAL SESSION

2:00 P.M., Presiding Officer—F. P. McKibben, Senior Vice-President, American Welding Society.

Welding of Piping in New York Hospital—Cornell Medical Clinic by a representative Almirall & Co.

Factors Effecting the Weldability of Steel, by Wilmer E. Stine, The Lincoln Electric Company.

Prepared discussion of paper "Factors Effecting the Weldability of Steel," by F. T. Llewellyn, U. S. Steel Corporation.

Friday, September 25th

Morning

TECHNICAL SESSION

9:45 A.M., Presiding Officer—P. P. Alexander, Chairman, Boston Section, Fundamental Research Committee, American Bureau of Welding.

Welding of Everdur Tanks, by Ira T. Hook, American Brass Company, and M. Powell, Whitlock Coil Pipe Company.

Semi-Automatic Gas Welding. A paper accompanied by two-reel motion pictures by a representative Linde Air Products Co.

Underwater Cutting. A lecture and motion picture, by Charles Kandel, Craftsweld Equipment Corp.

WELDING EXPOSITION

Commonwealth Pier

The Exposition will open at 12 noon on Monday.

It will open every day at noon and close at 10:00 P.M. every night except Thursday when it will close at 6:00 P.M.

LADIES' ENTERTAINMENT

Monday, September 21

Morning

Registration—Foyer—Main Corridor—Copley-Plaza Hotel. Commencing at 11:00 A.M. on Monday and continuing throughout the week between the hours 11:00 A.M. to 12 noon and 2:30 P.M. to 4:30 P.M.

Afternoon

12:30 P.M.—Assemble. Parlor A—Copley-Plaza Hotel for transportation to 1:00 P.M. luncheon at Statler Hotel, to be followed by a sightseeing trip through the Boston City parks.

Tuesday, September 22

Morning

10:00 A.M.—Assemble. Parlor A—Copley-Plaza Hotel for sightseeing trip to Concord and Lexington, returning 1:00 P.M.

Afternoon

3:00 P.M.—Trip to Pemberton by boat. Shore dinner and sports, returning in evening for moonlight sail. Transportation from hotel to pier by buses, leaving hotel promptly at 3:00 P.M.—Price $2.00 per person.

Wednesday, September 23

Afternoon

Choice of

12:45 P.M.—Assemble. Parlor A—Copley-Plaza Hotel for sightseeing trip, leaving at 1:00 P.M. through Boston, Brookline, Cambridge, Concord, Lexington and Wayside Inn, returning at 6:00 P.M.

or

2:00 P.M.—Theatre party tickets to be procured at registration desk.

Thursday, September, 24

Morning

10:00 A.M.—Assemble. Parlor A—Copley-Plaza Hotel for sightseeing trip around Boston, to Salem and Marblehead.

Afternoon

12:30 P.M.—Assemble. Parlor A—Copley-Plaza Hotel, for transporation to 1:00 P.M. luncheon at Waltham Watch Company.

Evening

6:30 P.M.—Annual Banquet followed by dancing—Ballroom adjacent to Foyer—Main Corridor—Copley-Plaza Hotel.

An Invitation

The Boston Society of Civil Engineers extends an invitation to any member of the American Welding Society who may wish to attend the regular meeting of that Society on Sept. 23, 1931, at which time an afternoon trip has been arranged to visit the United States Arsenal at Watertown to see the latest development in X-ray examination of welding and metallic structures, under the direction of Col. Tracy C. Dickson. The evening meeting will be held at 7.00 o'clock in Chipman Hall, Tremont Temple, Boston. Colonel Dickson will address the meeting on "The Work of the Watertown Arsenal." The usual buffet supper will be served at 6.00 p. m.

Welded Drums and Embrittlement

Abstracted from June 15, 1931, issue of Power Plant Engineering.

Research on embrittlement indicates clearly that several factors must be considered and that two definite conditions must be present simultaneously in order to produce this type of failure in boiler plate. The metal must be highly stressed, probably to the vicinity of the yield point and the steel must be in contact with a concentrated solution of sodium hydroxide. Portions of drums overstressed but in contact with soft boiler water are not endangered by embrittlement; neither are normally stressed sections in contact with highly concentrated solutions, as for instance in joints between plates.

Hammer welding or fusion welding eliminates the majority, in a good weld probably all, of the crevices where concentration can take place, so that, even though the metal might be highly stressed, the absence of concentrated caustic solutions would undoubtedly prevent embrittlement.

There remains, however, the danger of embrittlement around tube ends, where high stresses set up during rolling leave the metal in a condition susceptible to embrittlement because the boiler water concentrates in the small capillary spaces between the tube and drum. Embrittlement of this kind has been experienced and must be watched so that welded drums will not remove entirely the necessity for rigid conditioning and control of boiler water.

SERVICES AVAILABLE

A-137. All-around pipe welder desires position. Last place of employment with the Susquehanna Pipe Line Company.

A-138. General welder desires position. Have had twenty years' experience.

A-139. Combination welder desires position. Ten years' experience as welder, supervising, inspecting, setting up and laying out work, production work in structural steel, machinery, etc., alloy steels, shop and field. Six years with Rionda Sugar Co. in Cuba. Locomotives, mill and structural steel welding. Have working knowledge of Spanish language. For past two years structural steel welder on buildings, pipe lines and tanks in the west. Can furnish best of reference. Willing to go anywhere.

A-140. Welding engineer desires position. Am married. Have had nineteen years' experience in steel bridge and building construction; the last five of which were devoted exclusively to fabrication and erection of structural steel and ornamental iron by arc welding. Since 1926 have been in business for myself and have had experience in designing, estimating and selling welded fabrication and erection work. Can furnish references and further details as to experience.

A-141. Research and development engineer desires position. Have had eight years' experience as production manager on arc welding of steel tanks, and two years' experience in research and development work on flash welding of headers and fittings for the M. W. Kellogg Co.

A-142. Welding engineer desires position as engineer, foreman or instructor. Have had twenty years' experience in oxyacetylene, arc, hand and automatic and atomic hydrogen processes. Experienced in training operators. Have developed welding departments and assisted in development and research work.

A-143. Welding engineer desires position. Attended Worcester Polytechnic Institute and have been through test course of General Electric Company. Instrumental in developing automatic arc welding equipment for that company. Have acted as service engineer for automatic arc welding apparatus. Am 37 years of age. Have been active in Welding Society affairs.

(Additional Society Activities given on page 44)

Large Diameter Pipe Arc Welded for Water Distribution

By VINCENT P. MARRAN

✦ This paper was presented before a Joint Meeting of the New York Sections of the American Welding Society, American Water Works Association, and the American Society of Civil Engineers, at New York City June 9, 1931. Mr. Marran is Vice President and Chief Engineer, Walsh Holyoke Steam Boiler Works, Inc.

The steadily increasing demand for water and more water has made it necessary for engineers to increase the size of flow mains, looking well ahead into the future. Increase in population, increase in demand from unexpected sources, and decrease in capacity coefficient over a period of years, make necessary fairly large diameter pipe to meet the growing needs of practically every community. The distance water has to be carried makes it necessary that the construction be on an economical basis. The responsibility of having these mains so designed that no disturbance of flow can occur

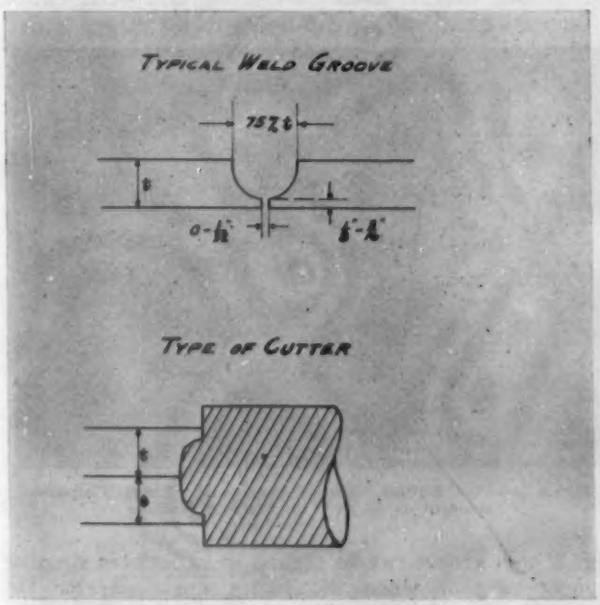


Figure 1—Method of Preparing Edges for Welding

makes it necessary to design for reliability. The ever-increasing traffic problem, excavations for new buildings, and increased pressures, makes it necessary to design for strength. In steel pipe we have the three qualifications named above, namely, economy, reliability and strength.

Steel is a finished product, the result of many years of experiment and study, and is delivered to the manufacturer in a finished form. It has, in a higher degree than any other material, desirable qualities. It is exceedingly strong, durable, elastic, resilient and tough, usable at all times, unchanging and reliable. Complete tests may be made during the course of manufacture that will enable the purchaser to insure that the steel

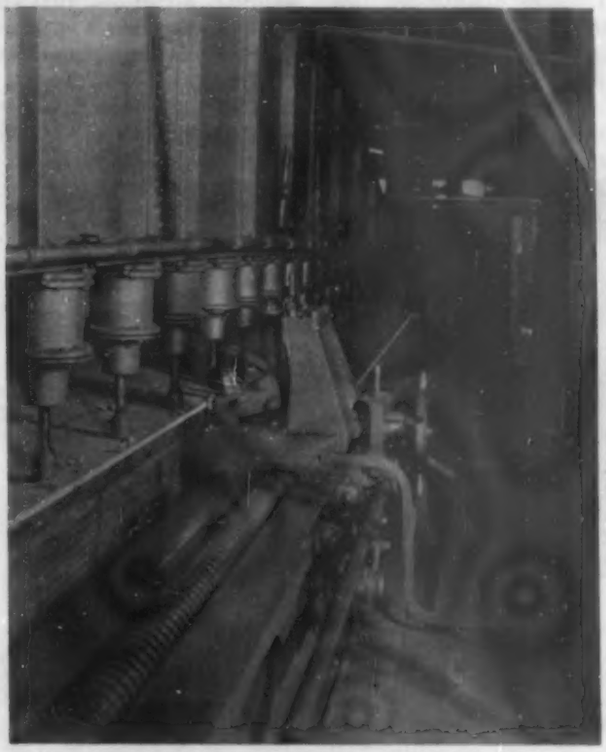


Figure 2—Planing U-Bevel on 2½ In. Plates

he purchases will meet all of the qualifications for the work that he has at hand. It remains to roll the steel in a circular form, joining the edges of the plates in a suitable manner, protecting the steel from corrosion, and we have a finished steel water pipe.

It is my intention to give you some idea of how we perform this latter function.

The longitudinal seam can be made by several processes. It can be made by lockbar construction. It can be made by forge welding, riveting, carbon arc welding, acetylene welding, or metal arc welding. I am going to follow through the processes necessary to arc weld the longitudinal seams, giving you as far as I can the procedure control and careful attention that will insure perfect results.

First, the selection of the material. The selection of the material depends on several factors, the confidence of the engineer in steel pipe, and the amount of money he has at hand to spend. I have had the privilege of being associated with installations using three different grades of steel, and I am frank to say that from a working standpoint, there is practically little difference. What will develop over a period of years, however, is another question, but personally I see no reason why the cheaper grades of steel are not fully as satisfactory as the more expensive grades.

The commonly accepted specification for steel is the specification compiled by the American Society for Testing Materials known as standard specifications for steel plates of structural quality for forge welding, serial designation A78-27. This steel is made in two grades, grade A and grade B, and, in my opinion, grade A gives us the more desirable steel, due to its lower carbon content. For your information, this carries no extra for quality, but may be purchased at the base price.

The second steel that is sometimes specified is covered under the standard specifications for steel plates

of flange quality for forge welding, serial designation A89-27. Grade A is preferable under this specification due to a lower carbon content. This steel carries a $3.00 per ton extra over the base price.

The third steel that is sometimes specified is indicated under standard specifications for boiler and fire-

Figure 3—Assembling by Tack Welding Two Halves of a 30 Ft. by 48 In. Dia. Pipe Before Going to Automatic Welder

box steel for stationary service, serial designation A70-27, selecting that grade known as firebox. This steel carries a $4.00 per ton extra over the base price.

The steel as outlined under serial designation A78-27 carries a chemical and physical check-up on each heat or melt of steel. The other two serial designations carry a chemical and physical check-up on each plate. It is natural to assume that inasmuch as the last two named steels each carry an extra in price for quality and that each carries infinitely more inspection, that the materials entering into their manufacture receive a little more careful checking. It is possible, however, to check up specification A78-27 so that one can be reasonably sure that the steel will meet all the needs for which it is designed. Surface defects may be insured against by employing suitable inspection, and the chemical check-up of each melt is really sufficient to insure that the entire lot of steel is satisfactory. All of the above steels work equally well from a welding standpoint.

Steel pipe is tailor made to fit the contour of the ground, and to fit the place where it is to be used. It is therefore necessary to have complete geometric data so that details of the steel pipe may be made before ordering the steel. The steel is then ordered in rectangular plates of the size required so that no waste whatever is encountered except in the special places where the tapering of some of the plates is necessary to form angles or special shapes.

It has been general practice up to the present time to make steel pipe up to 36 in. in diameter in one plate to the course. From 36 in. to 6 ft. it is usually made in two plates to the course. I mean by this that two plates from 30 ft. to 36 ft. in length are joined together so that the longitudinal seam will be either from 30 ft. to 36 ft. in length, with no intervening girth joints.

The reason for stopping at 36 in. in using single plates is due again to economy. It is general practice with the steel mills to sell steel under 100 in. in width at a base price. All steel wider than 100 in. carries an extra for width, and as a 36 in. steel pipe requires approximately a plate 118 in. wide, you can readily appreciate that this plate carries an extra of $3.00 per ton, and above this width it is more economical to make two longitudinal seams than to pay the steel mill for extra width.

Let us take a typical section and go through the processes that are necessary to get it ready for welding. We will assume that the field joints are to be riveted and the longitudinal joints metal arc welded.

Careful preparation of the plates before welding is just as essential as the weld itself. In fact, the actual welding is one of the shortest operations. In order to present the proper picture, it is therefore necessary to give you a general idea of the preliminary procedure.

The plate has been secured from the mill of the proper size to make a finished section. Usually these sections are made in what we call taper courses; that is, one circumference of the pipe is greater than the other end by seven times the thickness of the plate, so that the small end will fit in the large end for riveting. Templates are made, and the location of the holes for field connecting is prickpunched in the plate.

The plate then goes to the bevel shear and the ends of the plate are beveled. One end is beveled. The plate is then turned over and the opposite end beveled. This turnover is necessary so that the finished pipe can be caulked either inside or outside as desired. These plates then go to the planer to be grooved.

We have obtained excellent results using a "U" groove. This "U" groove is usually about $\frac{3}{8}$ in. wide at the top. This allows a lip at the bottom of the plate about 1/16 in. thick. Fig. 1 shows the general proportions of the groove that is used. By using a special cutter,

Figure 4—Two Multiple Arc Welders with Travel Carriages Mounted on 36 Ft. Pipe Welding Machine

Fig. 2, this groove can be planed in two plates simultaneously so that when the plates are separated the proper depth and width of groove is in the edge of the plate. It also gives us clean metal and a uniform surface to weld.

From this operation we go to the crimping press where about 12 in. of the plate along the sides of the longitudinal joint are bent to the proper radius of the desired pipe. This work is done in an hydraulic press, and is preparatory to the rolling of the pipe.

The plates are then put in a pyramid roll and, assuming we are using two plates to the section length, the plate is rolled to a half circle, the taper mentioned above being rolled in the plate at this time.

The fitting up of the plates preparatory to welding is very essential. There must be no pulling or twisting of plates to get the seams in alignment that will lock up any stresses in the plate itself, but the plate edges

must be so formed that when one plate sets on top of the other one the seam edges are in perfect alignment (Fig. 3).

In the forming blocks the edges of the two plates are tack welded to hold the two plates together in perfect alignment before welding. After tack welding the pipe is taken from the forming blocks and an inside

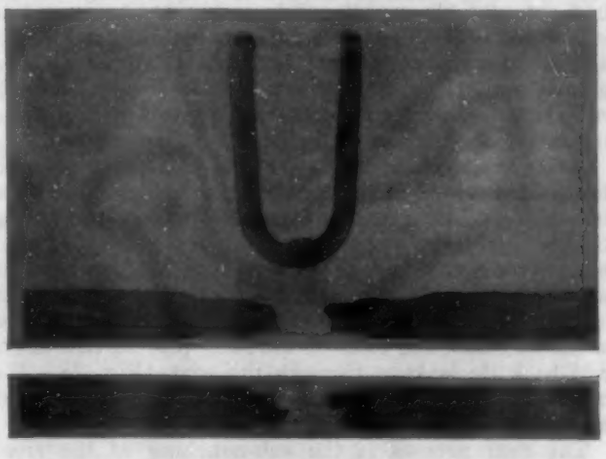


Figure 5—Average Tensile Strength of Above Specimens 73,100 Lb. per Sq. In. Average Elongation 18.5 Per Cent

bead is put on where the plates join together. This inside bead, incidentally, adds about 15,000 lb. per square inch to the strength of the joint. It holds the plates much firmer for the finished operation of welding and eliminates magnetic disturbance. The section is then ready to be placed on the welding machine.

The machine that we use carries a pneumatic backing-up bar and the cylinder is inserted over this bar, the machine locked and the pressure applied to the pneumatic cylinders. The pressure in this bar is about 1500 lb. per linear foot and holds the section to be welded firmly against the welding blocks.

Along each side of the heavy girders is a heavy copper bar known as the welding block, the two welding blocks being spaced about 2 in. apart. The machines that do the welding are carried on trucks supported by girders and the nozzles of the machines reach down between the girders to the central portion between the welding blocks.

We use four arcs on each machine, two arcs starting at one end of the pipe and traveling to the opposite end. These arcs are automatically controlled, using standard equipment, as shown in Fig. 4.

The number of beads that we apply to the welding groove depend entirely upon the thickness of the plate that we are welding. One-half inch plate requires two beads, and if our machine is using two arcs, the complete weld can be made in a single pass. By using four arcs, after one machine has traveled half the length of the pipe, the entire weld is completed.

The first bead, which we call our filler bead, carries usually a smaller wire, a bare wire of selected material that will fuse readily and develop the proper amount of heat, using a low voltage across the arc. If we assume that the pipe we are welding is ½ in., we would use a ⅛ in. electrode for our first pass having a voltage of 20 volts across the arc, and carrying approximately 300 to 320 amperes. Our second pass would travel about 8 in. behind the first arc and would carry a 3/16 in. electrode having a voltage of approximately 20 volts across the arc, and a current of about 350 to 360 amperes.

The electrode used on the second pass should be either a composite or a coated electrode. To insure proper penetration on the groove walls, this second pass electrode is oscillated. An electrode carrying a ⅞ in. oscillation will give us a weld width of about 1⅛ in.

In order to check up the quality of the weld metal and to be certain that the deposited metal has all of the necessary qualifications, test pieces are usually welded with every fifth pipe. These test pieces are grooved in exactly the same manner as the plate itself is grooved. The bottom side of the test plate is welded, constituting the inside bead, and the test piece is placed on the end of the section and welded continuously with the section. This test piece is usually large enough to give us six specimens for testing.

Three of the test pieces are planed for tensile pull, having the weld notched to insure the break occurring in the weld. This is done to determine the tensile of the weld metal.

We are really not interested at this time in the tensile of the plate, and yet so many specifications are written specifying that under tensile pull tests the welding specimen must fail in the plate. This gives us no true indication of the character of our weld. The point at this time that we are especially interested in is the strength of the weld. We have had the mill tests giving us the physical properties of the plate and now we are interested only in the weld itself. What is the tensile of it? How much stronger is this tensile than the tensile of the plate? Only in this manner, by notching out the weld, can these figures be determined. Incidentally, we learn more of our weld by notching the

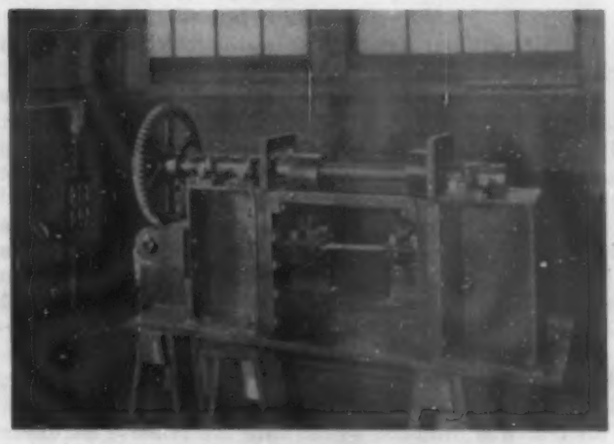


Figure 6—Fatigue and Bend Test Machine for Testing Sections of Welds in an Automatically Arc Welded Pipe

Figure 7—Hydraulic Testing Machine with 30 Ft. Long, 48-In. Dia. Pipe in Place

plate and breaking the weld than we do by letting the specimen break in the plate, and it will break in the plate unless the weld is notched. The broken weld specimen gives us an opportunity to study the character of the metal in the heart of the weld itself, and in this manner we have been able to secure some splendid results. Fig. 5 will show you some of the samples that have been pulled in this manner and the results obtained.

The second three test pieces are bent to determine whether the weld will stand abuse, and a properly welded specimen will stand a very sharp bend without fracture, depending, of course, on the thickness of the plate itself. On the thinner plates this weld can be bent flat

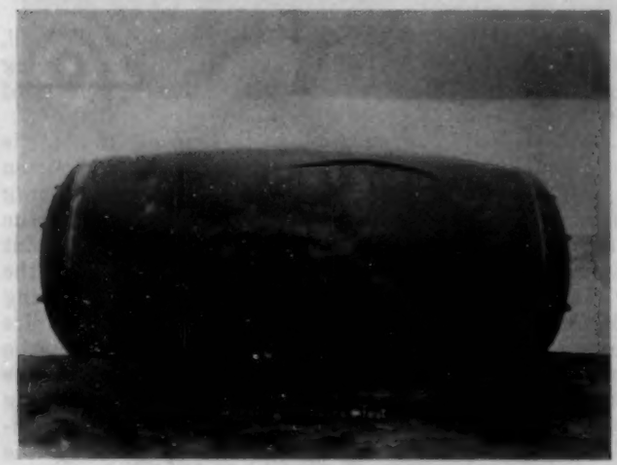


Figure 8—Vessel After Hydrostatic Test

on itself without fracture. In the thicker plates, of course, considerably more distortion is obtained.

Let me diverge for a minute to tell you about some tests on welded specimens that we conducted over about 6 miles of pipe. These tests were intended to develop hardness, pliability, so-called fatigue of weld and heat effect on the adjacent plate.

A machine, a picture of which is shown in Fig. 6, was developed, whereby one end of the test specimen was clamped between jaws 8 in. apart, one jaw being fixed and one jaw loose, with the weld 2 in. from the fixed jaw.

The loose jaw was then moved vertically up and down through a travel of 1 in. above and below the center, the number of strokes being counted to develop failure. This test was intended to indicate the relative hardness and pliability of the weld to the plate, and should failure occur in the plate rather than the weld, it would indicate the heat effect on the plate adjacent to the weld. For hardness and pliability we were not allowed under 30 strokes of the jaws to start perceptible fissure or flow of the weld, or should this movement indicate that the bond of the weld and the plate metal was not as strong as the metal in the weld, it was to be considered not acceptable.

The machine was then altered so that both jaws moved alternately up and down, and a test specimen with the weld centrally spaced between jaws inserted.

For fatigue we were allowed 75 strokes before failure to be the minimum for proving the work acceptable.

For heat effect, the ability of the plate to withstand a greater number of shocks or bends than the weld before failing was indication that the temperature stresses had not been too severe. This was really a very splendid test.

We conducted some 6000 tests of this nature and in every case where the test sample stood up under the abuse it was subjected to, the tensile and bend tests also gave us results of the highest order. Where any of the test pieces failed under these tests they usually failed in the tensile and bend tests.

Getting back to the weld itself, a good weld can be determined by visual inspection if the inspector has had considerable experience in welding. As an aid to visual inspection, scribe marks should be placed each side of the groove so that it would be apparent at a glance should the welder not have his weld perfectly centered. A perfectly centered weld is essential to insure penetration on both sides of the groove wall.

After the welding tests have determined the acceptability of the weld in the cylinder, the cylinder is placed in a hydrostatic press and water pressure applied to the desired pressure. Due to the fact that the rivet holes are not yet punched, the end of the pipe is usually placed against a lead or babbitt seat and an hydraulic ram forced against it to insure pressure enough against the ends of the steel pipe so that there will be little leakage through the seat (Fig. 7). We have yet to find a weld that leaks in this test after it has met all of the requirements for inspection.

The next process is the sub-punching of the rivet holes for field connection. Special punches are arranged so that the end of the pipe may be inserted in the dies and using a rotating sling the ends of the pipe are punched.

The next process involves the cleaning of the pipe. This process must be carried out very carefully and with the closest supervision. Pneumatic or electrically driven wire brushes are used over every square inch of the surface, both inside and outside, to remove mill scale or dirt that has collected during the various processes through which the section has passed.

Of course, there are other means of cleaning the surface of the pipe, sandblasting being one of the acceptable processes, but our objection to sandblast is that not only can the surface of the pipe be destroyed if the process is not carefully controlled but in order to be economical it should be automatic, and if it is automatic, there may be some places on the pipe that require more cleaning than others. This would mean the automatic process must be stopped when this spot is reached and the process slowed down until this spot

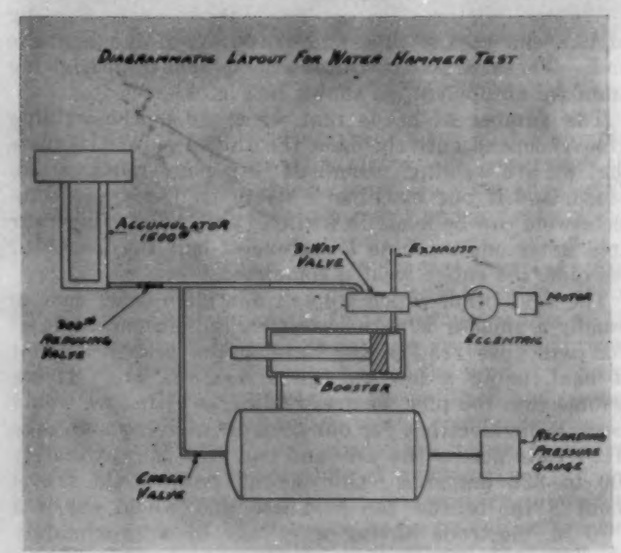


Fig. 9

is passed over, then brought up to its normal operating speed again.

Very careful figuring shows the costs of the two processes to be practically identical. More labor is used in the wire-brush method, but this is offset by the heavy power costs in sandblasting operations. This is one phase of manufacturing that is now under study.

If any grease spots are apparent, these grease spots must be carefully wiped off, using a solvent that will remove all trace of oil or grease.

The pipe is then ready for the dipping kettle. The kettle that we use is electrically heated and thermostatically controlled, both in the heating temperature and in the bath itself.

A chemical check-up of the pipe coating should be

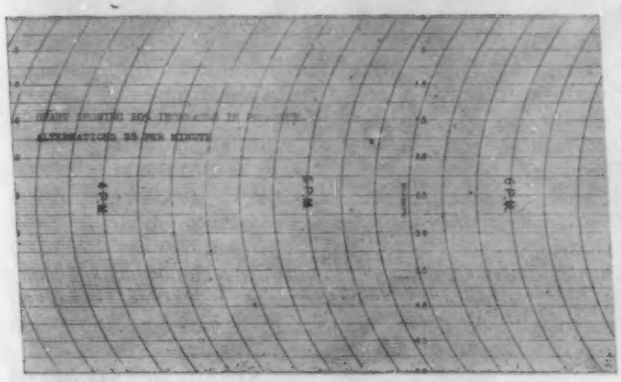


Figure 10

made at least once per day. This coating of necessity consists of a considerable amount of volatile oils that are driven off due to maintaining a high temperature during the dipping process. In order to keep that material at the proper consistency these oils must be replaced at least once per day. For this reason melt tests, by the float method, are made every morning and simple calculations determine the amount of oil necessary to replace that driven off. After the fluxing process the entire contents of the tank should be thoroughly agitated so that the fresh oil will be thoroughly mixed with the material in the tank.

To my mind, the dipping process and the results obtained from dipping are fully as important as having a strong and flexible weld. The life of the pipe depends on this coating being properly applied. Every coating used really has a critical dipping temperature. By this I mean a temperature that will not vary more than plus or minus 5 deg., and give the best results that can be obtained with that particular compound. Suitable control, therefore, must be provided to maintain the temperature of the bath within these critical points, if the best results are to be obtained. This can very easily be done. As a matter of fact, there is no reason why the temperature should vary more than 1½ deg. plus or minus, if proper control is applied.

The foregoing, as you can appreciate, has only touched the high spots covering the general procedure necessary for the making of large diameter arc welded water pipe. There are many side issues that time will not permit me to tell you about. One very interesting side issue, however, I will tell you.

About a year ago I suggested the use of a welded steel pipeline to serve as a penstock for an hydro-electric plant. The head on the plant was a little over 500 feet and operated under varying conditions. The penstocks were 8 feet in diameter.

The value of a weld to withstand the shock of surge was questioned. To prove that a weld was satisfactory, two model sections of pipe were made up. The sections were 42 in. in diameter by 10 feet long, made from ⅜ in. flange steel and the ends were capped with dished heads, the two sections being as nearly alike as it was possible to make them.

One section was subjected to a direct bursting pressure. The outside circumference was increased 26½ in. and the steel reduced to .204 in. in thickness. The break occurred through the plate, well away from the weld Fig. 8. Test samples were cut from the weld and shell for comparison with tests made on shell steel and the weld during the course of construction. The results were very interesting. The shell steel tested 54,400 lb. before the break and 72,800 lb. after. The weld that tested 66,000 lb. before the break tested 84,000 lb. after. All of the material had been strain hardened.

The second section was subjected to a water hammer test and then burst to destruction. The water hammer test consisted of maintaining a steady pressure of 300 lb. and applying 10,000 shocks of 20 per cent increase. To apply the shocks the following testing apparatus was rigged up (Fig. 9).

A 300 lb. reducing valve was connected to a 1500 lb. accumulator line and connected directly through a check valve to the section under test. A branch line also carrying 300 lb. was connected through a 3-way valve to a booster. This booster consisted of a piece of 10-in. pipe containing a traveling piston. To this piston was connected a rod large enough in diameter to take up just 20 per cent of the area. Thus, by applying 300 lb. to the back side of the piston, this pressure increased the pressure on the rod side of the piston just 20 per cent. The 3-way valve was actuated by a motor-driven eccentric giving 35 alternations per minute, so that the pressure was first applied and then the pressure side of the booster was exhausted to atmosphere, the piston sliding back to its original position, due to the 300 lb. maintained pressure, and the operations repeated. Fig. 10 shows the curve from the pressure recording gage. Each stroke of the booster forced 87 cu. in. of water into the test section and the pulsations of the shell were apparent to the eye. Ten thousand eight hundred pulsations were applied and then the section was burst to destruction. The bursting pressure did not go quite as high as the first cylinder, the shell tearing vertically and through the weld, letting go at around 60,000 lb. stress. This stress was sufficiently high to convince us that the shock the cylinder was subjected to had little or no effect on the ultimate strength.

I think you will appreciate that modern welding methods have made it possible for extraordinary development in water lines. As a matter of fact, we have merely scratched the surface. By careful and conscientious work welded steel pipe is being more generally accepted throughout the entire country and many of our conservative engineers are gradually being converted to its use.

The amount of money expended or to be expended along these lines makes it absolutely necessary that the engineer be sure of his results, and this can only be done by education. This industry, of course, is very young, and of necessity has to move slowly. Too much control or too much testing cannot be used. It will assist us all in the years to come to develop standard procedure that can be generally adopted by all. Any means we may take to effect results are justified, provided we secure economy, reliability and strength.

Arc Welding Makes Possible Steel Frame House of Practical Design

By A. F. DAVIS

✦ Mr. Davis is Vice-president of the Lincoln Electric Company, Cleveland, Ohio.

The arc-welded steel frame house recently completed in Cleveland is notable because of the sane and conservative engineering behind the design which allows the advantages of skyscraper construction at the same cost as traditional wood framing. In the past, efforts to build a steel frame house, be it clamped, clipped, bolted, riveted or welded, have been marked either by excessive cost or radical design, factors which hamper the spread of such a type of construction.

The house in Cleveland, however, is not a freak or

Figure 1—Perspective Drawing of the Arc Welded Steel Frame House

experiment of any kind. The materials and methods of construction have all been tried and tested in other fields. No new materials or patented processes are embodied in this dwelling. Building experts and engineers who have inspected the house declare that the design is thoroughly practical and that the advantages of this type of construction are so great that it will soon come into wide use.

Designed for economy

George Howard Burrows, A. I. A., specialist in residence building, designed the house, a seven-room structure of Norman-French architecture. Plans were drawn for welded steel or wood frame construction, and the contractors bid on both types. The figures follow:

The requirements of Norman-French architecture set up a rigid test for the versatility of arc-welded steel framing. It was the belief of the architect, however, that steel could and should be handled on the job as easily as lumber. A perspective drawing of the house, which is located in the exclusive Shaker Heights district, is shown in Fig. 1.

In designing for arc-welded steel framing the elimination of shop fabrication, ease of handling, and speed of erection were considered. The use of steel allowed stronger and more economical wall and ceiling construction. A wood frame house of the same physical properties would exceed steel framing in cost. The isometric drawing, Fig. 2, shows the details of construction. Wherever possible the connections are direct bearing and the welds in compression. The third floor framing required welds in shear and fabrication before erection. The only other welds in shear occur where the heavy joists, cut to short lengths at the mill, were spliced to carry over a long span.

Contract.	Brick veneer frame construction.	Brick veneer steel construction.
Excavating, rough grading.....	$315.00	$315.00
Finish grading, lawn and drive..	235.00	235.00
Masonary—cement, iron, walks, stone	2,820.00	3,395.50
Structural steel	180.00	881.50
Steel—sash and screens.....	404.00	404.00
Carpenter labor	1,400.00	1,000.00
Rough lumber	1,185.00	432.00
Finish lumber	1,025.00	1,025.00
Floor scraping	80.00	80.00
Plastering	800.00	615.00
Wiring	335.00	420.00
Tinning	285.00	285.00
Painting	520.00	520.00
Plumbing	1,275.00	1,275.00
Heating	850.00	850.00
Ornamental iron	150.00	150.00
Tile	361.00	361.00
Mantels	40.00	40.00
Weatherstripping	28.00	28.00
Caulking	25.00	25.00
Garage doors	100.00	100.00
Cabinets	35.00	35.00
Composition roof	60.00	60.00
	$12,508.00	$12,532.00

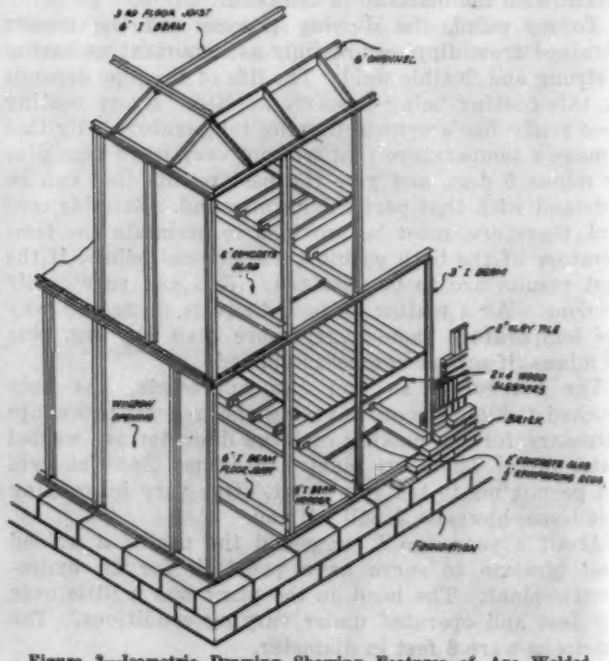


Figure 2—Isometric Drawing Showing Features of Arc Welded Steel Frame Construction

Figure 3—Detail of Welding on First Floor Joists and Sills

The hollow enclosure brick and tile walls carry the bronze certification of the Common Brick Manufacturers Association of America and, according to Lee H. Miller, chief engineer of the American Institute of Steel Construction, are the finest possible for steel frame residence building. The ceilings are poured reinforced concrete, with wood sleepers placed across the steel floor joists to carry the sub floor. This allows piping and wiring in either direction without cutting.

The design and steel erection were approved by Louis K. Whitcomb, structural engineer for the Carnegie Steel Company, and representatives of our company.

Steel erection simplified.

The steel, cut to specified lengths at the mill, was delivered on the job like lumber. Three steel workers, one of them a welding operator, erected the 20,296 lb. of steel with no other tools than a welding machine and leveling devices.

The steel framing consists principally of 3-in. 5.7 lb. Carnegie I-beams, which served as sills; 3-in. 4.1 lb. Carnegie channels, used as studs; and 6-in. 12.5 lb. Carnegie I-beams, which served as floor joists. The sills were laid directly on the masonry foundation walls. The floor joists were laid on the sills at 4-ft. centers. Details of this welding are illustrated in Fig. 3. The short tack welds needed to secure the floor joists required the minimum of welding. Fig. 4 shows the erection of studs for the first floor walls and partitions and at the right of the photograph the sills for the second floor are being fused into position. The studs were welded along two sides of the inner face of the channel.

Where the span was great the floor joists were carried on 8-in. I-beams supported by 4-in. I-beams, which served as columns in the basement. The floor joists on the second floor required some butt welding, as the steel for the upper floors had been cut in lengths below 25 ft. in order to allow manual erection. These connections and the third floor framing are the only joints in the structure in which the weld is in shear.

The steep pitched roof required a reduction in the area of the third floor which necessitated the complicated framing shown in Fig. 5. The 4-in. I-beams which carry the floor joists to the studs were cut at the mill and are welded to the 6-in. floor joists on the ground. For lateral bracing an angle was tacked to the floor joists. The corner studs on the first floor were also braced. Three-inch 4.7-lb. I-beams were used as studs on the corners.

Figure 4—Studding for First Floor Walls in Place, Showing Erection of Second Floor Sills

Figure 5—Framing Caused by Reduction of Third Floor Area

Figure 6—Complicated Framing Required by Offset in Front Exterior Wall

The rear masonry wall is carried on the frame on the second floor. The only cutting required in this erection was needed to frame an offset in the front exterior wall, the complicated framing for which is shown in Fig. 6. This cutting was done with a carbon arc and the strength of the connection is insured by a small angle arc welded at the joints.

The welding on the structure was a test, more of the ability of the operator as an iron worker, than of the electric arc process itself. The design for direct bearing connections allowed the minimum of welding, the builder figuring the welding time for each connection as about the same as for nailing; with the steel requiring fewer members and little cutting.

Steel framing allows a superior wall construction, shown in Fig. 2. The outer shell is composed of 4 in. of face brick; the inner shell, which serves as a base for plaster, consists of 2-in. hollow tile. A 3-in. dead air space, the depth of the steel studs, provides perfect insulation. The masonry is tied in the frame with clips, embedded in the mortar and wedged to the flange of the channels. The brick is reinforced laterally with steel pencil rods. This 9-in. wall is independent of the frame, and may be cut or changed as the owner desires.

Steel frame construction insures a home which will not shrink, sag or warp. If the foundation settles irregularly, the frame, arc welded into a single unit, will not be moved. It is expected that because of the insured permanency of this house bankers and mortgage companies will favor this type of construction. The spread of this type of construction will open up a potential market for structural shapes greater than any present outlet. With the adoption of steel roof framing of practical design and low cost, and the use of "battleship deck" flooring, consumption of structural steel may reach 3,000,000 tons annually.

Building experts and steel engineers feel that this type of construction, made economical with the aid of arc welding, will eventually supplant traditional methods.

Copper Welding Solves Refinery Problem

By DONALD R. PRATT

✦ Mr. Pratt is connected with the Linde Air Products Company.

AN interesting application of copper welding has recently been made by a large Southern California refinery in the fabrication of still heads and piping for special process stills where hot zinc chloride is used.

Preliminary experiments had to be made in order to determine the type of material that would resist the action of the zinc chloride most satisfactorily. Brass was out of the question as the hot zinc chloride disintegrated it in a very short period of time. Lead was found to be very satisfactory, but due to the high pressure necessary for the process and the size of the pipe and fittings needed, it was found difficult to support this material so that it would not collapse. Sheet copper was then thought of by the company's welding superintendent, who suggested the welding of rolled sheet with copper welding rod. In this way, he pointed out, all of the necessary 20-in. diameter pipe and fittings could be fabricated as well as the linings for the still heads.

10-Ft. Diameter Copper Lining in Dished Head, Completely Welded

The refinery shop tried welding a few test pieces of copper with ordinary copper welding rod, but their results, although good, were not as satisfactory as

20-In. Tee Fabricated from Sheet Copper by Welding

could be desired. A phone call to their oxygen manufacturer's district office quickly brought an oxy-acetylene welding service operator. After checking over the work that they had done, he suggested the use of a special copper welding rod. Test specimens were welded with this rod and were found to be perfectly satisfactory as to strength, soundness and resistance to the action of zinc chloride. Steps were immediately taken to proceed with the fabrication of the necessary equipment by this method. While the material was being prepared, the service operator instructed the plant welder in the proper procedure for welding copper.

The large 10-ft. diameter conical head for the main still was of steel construction lined with copper. Six segments of ⅛-in. copper sheet were cut to form the lining. These were then placed in the head and held in correct alignment with copper staybolts. After the segments had been welded together, the heads of the staybolts were welded to the sheet in order to hold the lining in place and to insure tightness of the head. There were also three similar dished heads 8 ft. in diameter for smaller stills,, lined with copper by welding in the same way, except that the lining segments numbered only four per head. Altogether in the fabrication of these heads there was 155 linear feet of oxy-acetylene welding.

The bodies of the stills consisted of steel shells lined with acid-resisting brick so that they did not require lining with copper.

There were also six 20-in. diameter flanged tees, and several sections of 20-in. diameter pipe varying from 20 to 10 ft. in length all rolled from ⅛-in. copper sheet and welded.

Several 16 by 24-in. steel nipples were lined with sheet copper, the welding of the seams being done after the lining had been formed in place within the nipples. One length of 16-in. diameter steel pipe 8½ ft. long was also lined with copper. This was a little more difficult to handle since it was necessary to weld from both ends, but under the supervision of the service operator, it was readily done by the plant welder. This type and fitting work required in all about 175 linear feet of welding.

The flanges were all cut by the oxy-acetylene process from steel plate.

The entire job required about 16,000 lb. of ⅛-in. copper sheet and about 300 lb. of special copper welding rod. In two weeks the whole job had been completed by one welder who had never had any copper welding experience prior to this. The entire equipment passed a test of 75 lb. per sq. in. hydrostatic pressure, thus illustrating in a unique way not only the ease with which high strength welds can be made in copper, but also the adaptability of the oxy-acetylene process from the welder's viewpoint.

Fabrication of Pipe Specials

By **OWEN C. JONES**

✦ Mr. Jones is connected with the Technical Publicity Department of the Linde Air Products Company.

THE possibilities inherent in the use of the oxy-acetylene welding and cutting process for the fabrication of pipe specials are limited only by the ingenuity of the designing engineer, the erection engineer or the welder. Special and odd shaped fittings which might take weeks to pattern, mold and cast, can be quickly fabricated with the blowpipe, either in the shop or right on the job. Welded construction reduces the weight and space that would otherwise be necessary, so that decided savings in time of erection and in cost are effected. Examples of the effective use of welded pipe specials are found in practically every industry.

Unusual precision and excellency of workmanship marked the fabrication of 22-in. and 26-in. pipe specials for a natural gas line by a company specializing in piping installations. This work also included the production of welded bends and orange peel type bull plugs. Procedure control methods were followed throughout.

One of the specials consisted of a length of 22-in. pipe with a Van Stone type flange at one end and a 26- to 22-in. reducer at the other. This reducer was fabricated from a short length of 26-in. pipe. The number of cuts required in making the reducer was first calculated from the formula:

$$N = 4/3\ (D_1 - D_2)$$

where N is the number of cuts, D_1 and D_2 the diameters of the largest and smallest pipes respectively. This formula gives 5 as the number of cuts to be made. A templet was then laid out and the cuts made according to the templet, using a cutting blowpipe. The cut edges were beveled, and scale from the cutting operation removed. Using a welding blowpipe flame, the segments were then heated, swaged into contact, and welded together. The smaller end of the reducer was welded to the 22-in. section of the special with a single vee butt weld.

(*Continued on page* 44)

Alligator Header for Brine Distribution Easily Fabricated by Welding and Cutting

COMMITTEE ON WELDED RAIL JOINTS

Progress Report No. 7
May 1931

A Summary of Tests and Reports

Organization:

The American Electric Railway Association and the American Bureau of Welding* united in an authoritative investigation of various types of welded rail joints in commercial use through a thoroughly representative committee which was organized late in 1921. This committee has a membership of about sixty individuals, including Way Engineers of several of the larger street railway companies, representatives of manufacturers of welded joints and welding equipment, welding experts, scientists and testing experts.

Dr. G. K. Burgess, then head of the Division of Metallurgy, Bureau of Standards, and now Director of the Bureau of Standards, was elected chairman. E. M. T. Ryder, Way Engineer of the Third Avenue Railway System, was elected vice-chairman and W. Spraragen, secretary of the Division of Engineering, N. R. C., and the American Bureau of Welding, was appointed executive secretary. Inasmuch as it was impossible to have this large committee meet more than once or twice a year, the administration of the affairs of the committee was left in the hands of a small representative Executive Committee.

Relation of American Electric Railway Engineering Association:

About $24,000 was contributed by the American Electric Railway Association, interested manufacturers, and a number of the larger street railways. The Association is acting as treasurer for the funds. Expenditures are made upon authorization of the Executive Committee and the bills are countersigned by the secretary and the vice-chairman of the committee and by a member of the Executive Committee of the American Electric Railway Engineering Association.

Objects:

The primary object of the committee is to improve each type of welded rail joint rather than to make comparative tests on the relative merits of the different types of joints.

Progress Report No. 1:

In order to compile a summary of the "present state of the art," a questionnaire was prepared on five types of welded joints in commercial use (cast, butt, bar, electric seam and thermit) and members of the committee were circularized. Answers to the questionnaire were correlated and a progress report of 73 pages printed in May, 1922. Typical problems needing further investigation were also included in the report.

*The Bureau is the welding research department of the American Welding Society and the Division of Engineering, National Research Council.

Preliminary Programs:

It was agreed that the next step was to test out joints representing the "present state of the art" by testing joints of each type made by representative street railway companies and by the manufacturers. Tensile, drop, repeated impact, bend and conductivity tests were made on each type of joint. In order to distribute the work the Bureau of Standards made the conductivity, repeated impact and tensile tests and also metallurgical examinations. Purdue University made the bend and conductivity tests and the University of Illinois the drop tests.

Progress Report No. 2:

Progress Report No. 2 was published by the committee in March, 1924. It consists of seventy-one printed pages and includes information on the organization of the committee; instructions issued to railway companies for making up test joints for the committee; methods of procedure and results in making tensile, bend, drop and conductivity tests; data furnished by the makers of these joints; photographs of specimens broken by the various tests and the discussion of the report.

Progress Report No. 3:

The Third Progress Report of the Committee on Welded Rail Joints, published April, 1925, contains findings of the committee, test data and other material of interest to the committee. Specifically it includes the remainder of results on tensile, bending and drop tests made on specimens to determine the present state of the art. The first results obtained from the repeated impact testing machine, as well as preliminary tests on the telemeter, are recorded in the report. In addition, there is also included the report of the joint examination subcommittee which carefully examined macroscopically and microscopically broken specimens; and the report of the sub-committee on Development whose function it was to draw up a program to test out the variables which affect the quality of the seam welded type of joint. The report contains 136 printed pages.

Progress Report No. 4:

The Fourth Progress Report is devoted exclusively to the test data and findings of the committee in connection with the repeated impact tests made to determine the present state of the art. This report includes a description of the method of operation of the repeated impact testing machine, charts showing location of failure, number of blows necessary to cause this failure and photographs of the broken joints. The report includes also, discussions by several individual members of the committee. It consists of 35 printed pages and was published July, 1926.

Progress Report No. 5:

The Fifth Progress Report consisting of 63 printed pages includes a series of shear test results made by the committee to develop a joint plate and method of welding, which would give a maximum area of cross section of soundly fused weld metal in the seams. The report also includes a program of additional investigations proposed by the

*The Bureau is the welding research department of the American Welding Society and the Division of Engineering, National Research Council.

cross section of soundly fused weld metal in the seams. The report also includes a program of additional investigatibns proposed by the

committee and a description of some preliminary telemeter tests made to determine stresses in rail joints under conditions simulating various degrees of poor joints and also test joints subjected to blows from the repeated impact testing machine. Published April, 1927.

Progress Report No. 6:

The Sixth Progress Report of the Committee includes results of repeated impact tests made on rail joints under a variety of conditions, the results of telemeter tests, and some preliminary preheating experiments. There is also included a series of strain gage measurements, the results of the tests of the "Walker" joint and some special impact tests on joints having no contact surface, as well as a second report on the shear test results. There are also given several miscellaneous reports of interest to the Committee. It consists of 89 printed pages and was published September, 1928.

Progress Report No. 7:

This present pamphlet is the Seventh Progress Report of the Committee. It does not include any of the results previously reported in Progress Reports 2 to 6 inclusive. The report includes a study of the heat effects of thermit welds on the adjacent rail material; the effect of preheating and postheating welded specimens and rail joints; additional repeated impact tests of joints and a study of butt joints and fish plate joints made with the atomic hydrogen process. The report also includes a study by Professor Lawson of stresses and distortions due to the heat of welding of low carbon to high carbon plates.

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 28
to
Members of Subcommittee
on

Preheating and Postheating

Committee on Welded Rail Joints

Some question has arisen as to the purpose of the preheating and postheating tests outlined in Progress Report No. 26. Essentially, these tests should show the difference in the *quality* of the weld metal, placed under different temperature conditions. The quality is measured by the shearing strengths of the welds in pounds per linear inch. That condition of preheating or of postheating, which, on the average, gives the highest shearing strength, produces therefore the best weld.

It must be recognized, however, that this best condition as found for these small specimens does not necessarily insure that the same conditions will be the best for welding rail joints. On the one hand, if, say, a pre-heating temperature of 400 degrees was found to give twice as high a

strength in a small specimen as for a similar specimen welded at room temperature, it might be that only a small increase in strength would be found for a rail joint which had been preheated to 400 degrees as compared to one welded without preheating. This might be because of the methods of temperature control for the joint, the relatively long time necessary to complete the welding, or the conduction of heat along the rail or to the ground. From this standpoint, the best condition for the small specimen would probably also be the best condition for the joint, but less differences in strength would be expected in the rail joints.

On the other hand, production of locked up stresses in the metal adjacent to long welds as in a rail joint might bring about a very different condition from that produced by the same temperatures in a short piece. This might be due to the mass effect or to the difference in conditions which takes place during the time the weld is being made. A certain

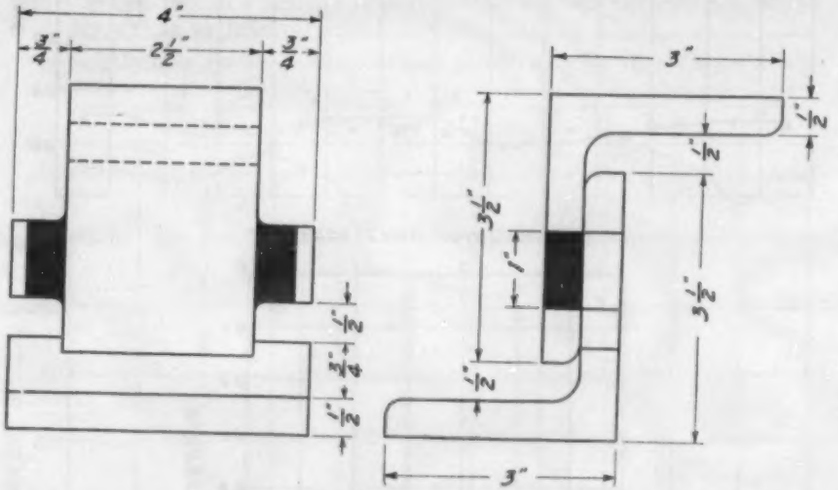


FIG. 1—SHEAR DETRUSION TEST SPECIMEN

temperature applied to a point in a large plate for a given time, for example, might be expected to produce different effects in the metal at that point from those produced by the same temperature applied to a point in a smaller plate for the same time. Thus it seems possible that if two preheating temperatures gave equal strengths for the small specimens. one of the temperatures might be considerably better than the other for welding a rail joint.

The tests of the small specimens should therefore show the variation in the quality of the weld metal for different preheating or postheating temperatures. Tests could then be made with specimens having longer seams or with rail joints to determine whether the best conditions for the small specimens were also satisfactory for the larger specimens.

At Mr. Spraragen's suggestion, the program has been expanded to

study the effect of preheating and postheating when both parts to be welded are soft steel. The form of these specimens is shown in Fig. 1. Brinell hardness determinations will be made on each angle piece and several tensile specimens from the material will be tested as a matter of record.

The Capital Traction Company has offered to furnish pieces cut from rails for the high carbon parts of the specimens mentioned in Progress Report No. 26. It is understood that the part to be welded to the angle will be the web of the rail and a portion of the rail base will be left attached to this web. This will allow the load to be applied directly over the welded seam without eccentricity.

H. L. WHITTEMORE, *Chairman*,
Subcommittee on Preheating and Postheating.

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 29
to
Executive Committee,
Committee on Welded Rail Joints
on

Hardness Tests Along a Thermit Welded Rail Joint

As there has been some interest in the hardness of the head of a thermit welded rail joint, tests were made on one joint.

A thermit rail joint, M and T, 12-1, originally submitted as representing "The Present State of the Art" series, but which had not been

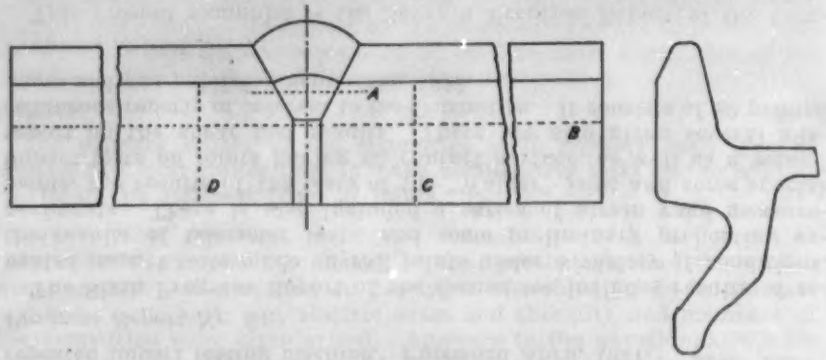


FIG. 1—LOCATION OF LINES ON RAIL HEAD

tested, was used for the hardness determinations. The top of the head was ground until the top horizontal surface was 2 inches wide. This decreased the height of the rail by less than ⅛ inch.

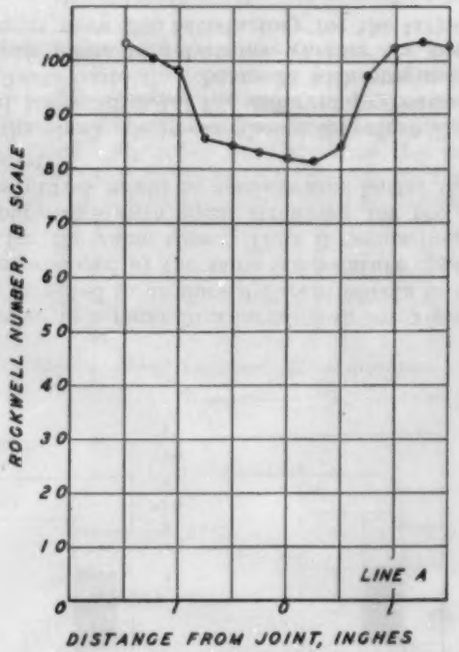


FIG. 2

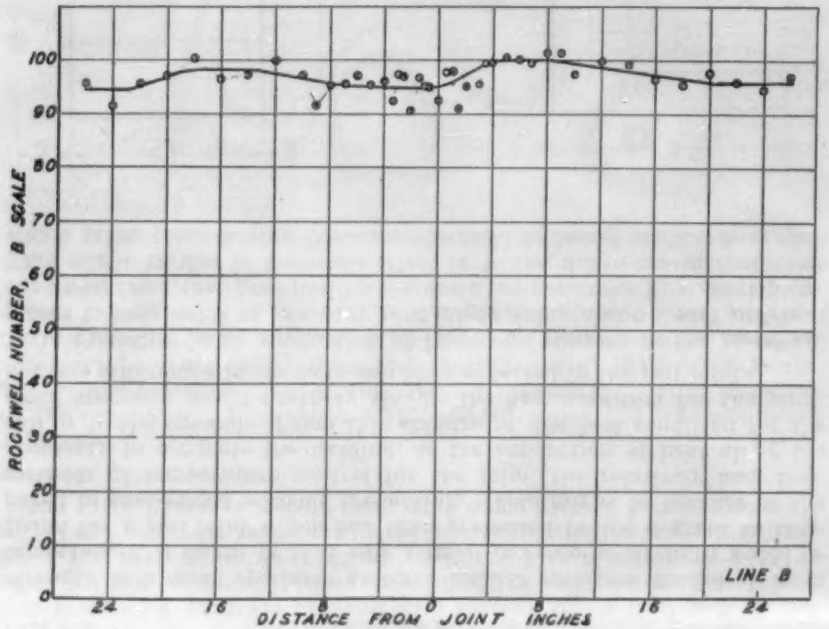


FIG. 3

was ground until the top horizontal surface was 2 inches wide. This decreased the height of the rail by less than ⅛ inch.

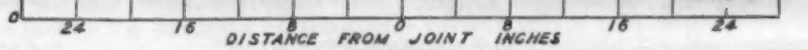


Fig. 3

A Rockwell hardness testing machine, with a 1/16 inch steel ball and 100 kg. load was used for all of these tests.

The hardness was determined along several lines, as designated on Figure 1, on the flat portion of the rail head. Figure 2 shows the hardness numbers along line A, ⅞ inch from and parallel to the outside edge of the rail head (opposite the lip). The thermit metal extended about

Fig. 4

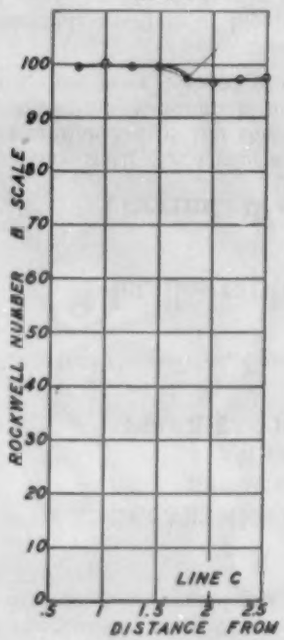
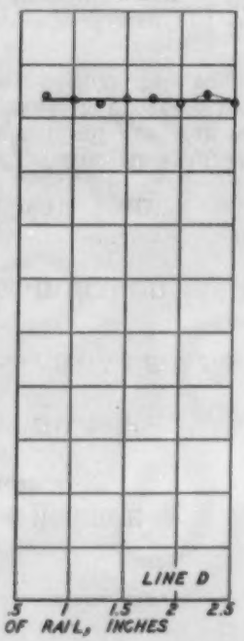


Fig. 5



¾ inch from the joint on this line. Fig. 2 shows that the thermit metal was not as hard as the rail steel near it.

Since the rail joint specimen had been smoothed off along its entire length, it was thought desirable to obtain hardness measurements along this entire length. Figure 3 shows these hardness numbers along line B, 1½ inches from the edge of the rail head. This line did not cross the thermit metal but did cross the insert which was 9/16 inch wide. The hardness numbers are fairly uniform along the length of the rail. In studying Figure 3, it should be remembered that a rail joint is fairly heavy and that it is difficult to balance a specimen of this shape on the base of the Rockwell hardness testing machine. Minor variations in hardness should therefore be attributed to errors in testing.

Figures 4 and 5 show hardness numbers on lines C and D, two inches from the joint across the ground flat portion of the rail head. There is only a slight tendency for the hardness to decrease as the distance from the edge of the rail head increases.

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 29A
to
Executive Committee,
Committee on Welded Rail Joints
on

Hardness Tests Along a Thermit Welded Rail Joint

In commenting on Progress Report No. 29 on this subject, Mr. E. M. T. Ryder writes as follows:

"In looking over the accompanying blue prints, we note that Figure 2 indi-

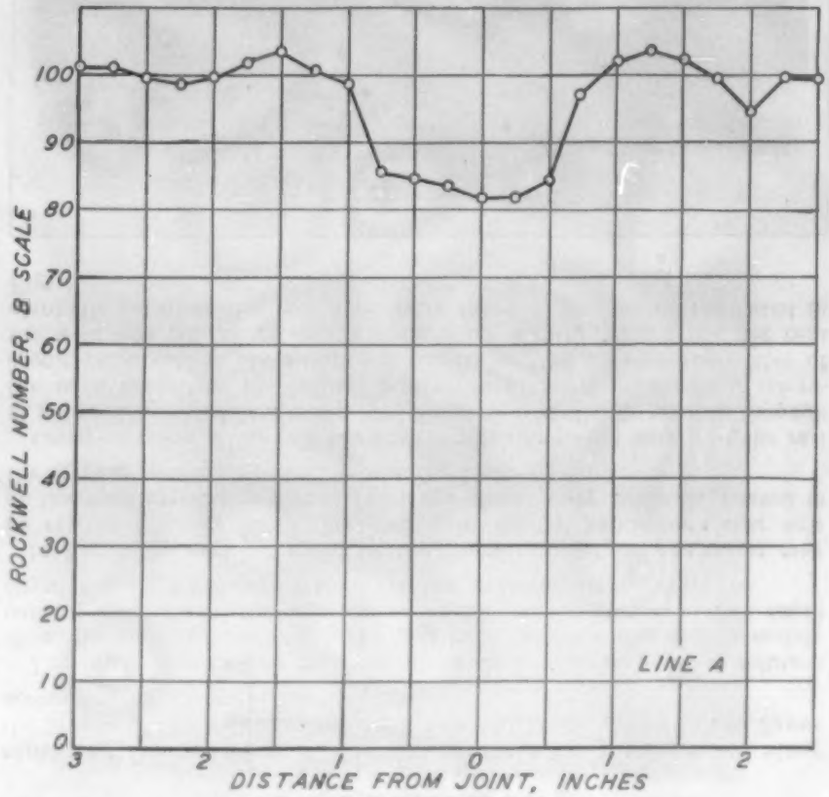


Fig. 1

cates Rockwell hardness in excess of 100 for a short distance on each side of the thermit metal. Figures 3, 4 and 5 do not indicate any hardness in the rail in excess of 100.

"We would like to suggest that line A, Figure 1, be extended and that additional readings be taken of this line to see if the hardness drops down to the level of or below 100, and at what distance from the thermit metal. It may be that the heat of the welding operation has hardened the rail locally, and this question should be definitely answered."

After the hardness measurements had been made along line B (refer to P. R. No. 29), a section of the rail at the joint about 6 inches long was cut out and the web and base cut off in order to obtain a slab of steel more suitable for the Rockwell determinations than the entire rail joint. The measurements along line A have been extended as shown in the accompanying Fig. 1. These Rockwell numbers seem to indicate that at a few inches from the thermit weld, the hardness of the rail head near the outside edge becomes practically constant. If a further extension of line A is considered desirable, slabs can be cut from the remaining rail ends.

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 29B
to
Executive Committee, Committee on Welded Rail Joints
on

Metallographic Examination
of
Thermit Welded Rail Joint

In accordance with Mr. Ryder's request of November 13, 1928, metallographic examination of the thermit welded rail joint for which hardness determinations were made and reported in Progress Reports Nos. 29 and 29A, has been carried out. The report of this examination is enclosed.

A considerable number of hardness surveys of standard rail sections have been made by Mr. Freeman of this Bureau as part of the study of rail steel. These results are summarized on page 394 in the Technologic Paper, 363, "Endurance and other Properties of Rail Steel."

Metallographic Examination
of
Thermit Welded Rail Joint of Progress Report 29A

It was requested that a microscopic examination be made at points 1½-in., 2¼-in. and 3-in. from the center of the weld with the view of

explaining the variations in Rockwell hardness which were found along the length of the rail near the weld and which are shown in the figure accompanying Progress Report 29A.

The top of the rail as received was etched with an aqueous solution of ammonium persulphate. The following photograph, approximately natural size, shows the appearance of the etched surface. The small circular spots which are visible are the Rockwell impressions.

In Fig. 1 the areas occupied by the fused-in metal and the insert may be readily distinguished. The two light colored bands on either side of the weld about two inches from the center were evidently heated to the critical temperature by the welding heat.

Cross-sections of the rail head perpendicular to the length of the rail at points 1½-in., 2¼-in. and 3-in. (the section at 2¼-in passing through the band heated to the critical temperature) were polished for microscopic examination. In addition a similar section through the center of the weld was polished. Micrographs, after etching with a five per cent alcoholic solution of picric acid, were taken at the points indicated in Fig. 1.

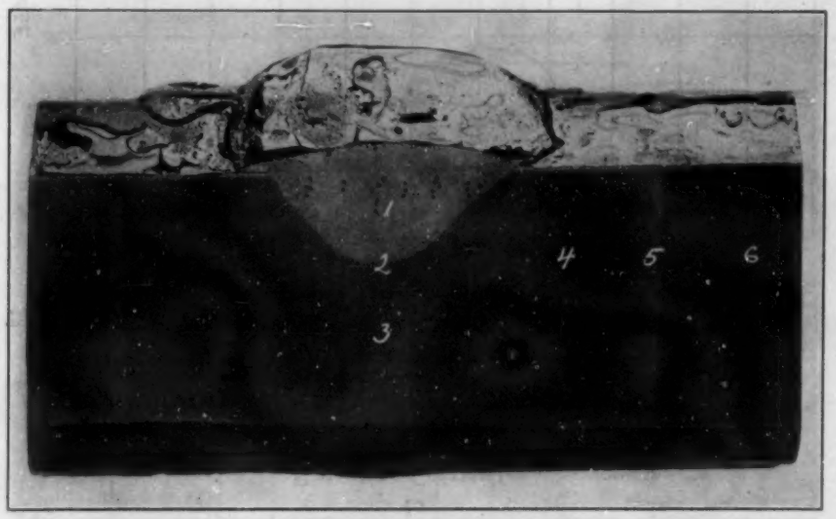


FIG. 1—TOP OF RAIL AS RECEIVED AND ETCHED WITH AN AQUEOUS SOLUTION OF AMMONIUM PERSULPHATE

A careful comparison of the structures along the lengths of the sections at positions 4 and 6 revealed no differences which could be considered of significance in explaining the slight difference in hardness which was found between the two positions. The structures along both sections as shown in Figs. 5 and 7 were what might be called troostopearlite. This structure at magnifications of about 500 diameters is

It was requested that a microscopic examination be made at points 1½-in., 2¼-in. and 3-in. from the center of the weld with the view of

practically unresolved, as shown in Fig. 8; no differences in structure could be detected between position 4 and 6 in Fig. 1.

As shown in Figs. 6 to 9, however, there was an appreciable difference in structure between positions 5 and 6 in Fig. 1. In position 5 the

FIG. 2—FUSED-IN METAL POSITION 1 IN FIG. 1, × 100

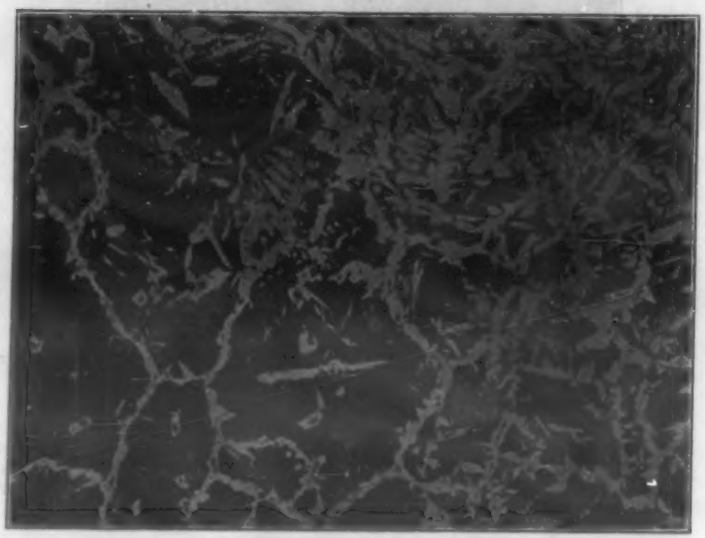


FIG. 3—JUNCTION BETWEEN FUSED-IN METAL AND INSERT. POSITION 2 IN FIG. 1, × 100

grain had become considerably smaller as shown in Fig. 6 as a result of the heating at the critical temperature. It is probably true that in the structure in question there is a relation between the extent to which the structure is resolved and the hardness, the more resolved structure being the softer. As may be seen by comparing Figs. 8 and 9 the struc-

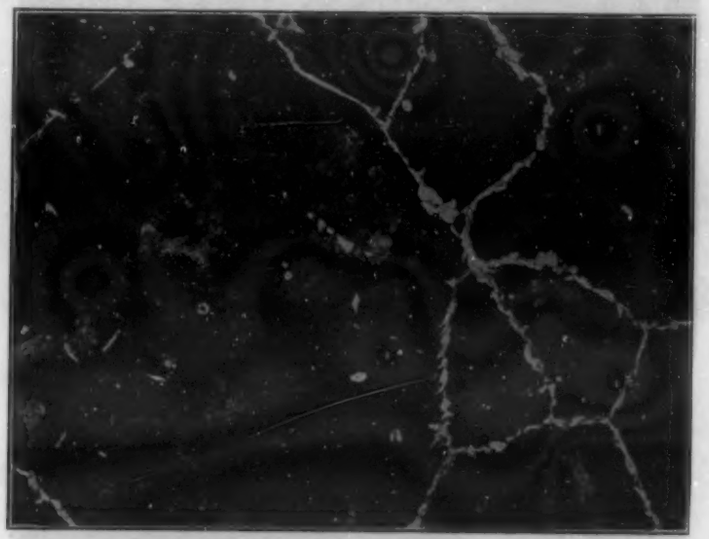


FIG. 4—STRUCTURE OF INSERT. POSITION 3 IN FIG. 1, × 100

FIG. 5—STRUCTURE OF RAIL AT POSITION 4 IN FIG. 1, × 100

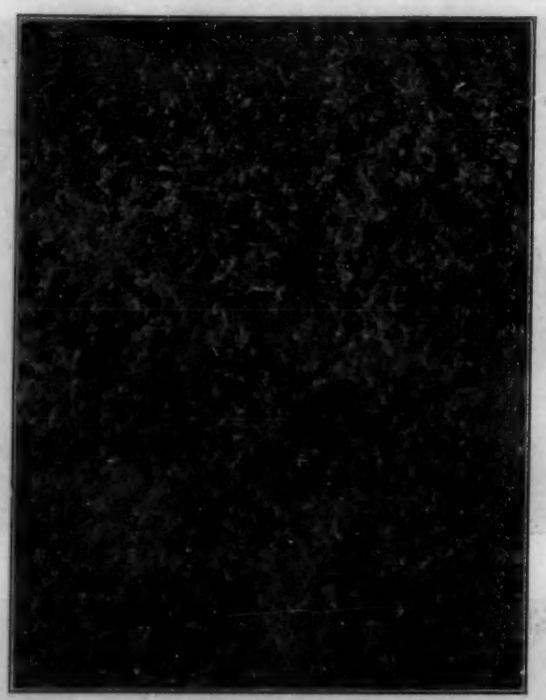


FIG. 6—STRUCTURE OF RAIL AT POSITION 5 IN FIG. 1, × 100

FIG. 7—STRUCTURE OF RAIL AT POSITION 6 IN FIG. 1, × 100

ture at position 5 is somewhat more resolved than that at position 6. This probably explains the difference in hardness which was observed. The difference in structure between Figs. 8 and 9 is not very marked, the difference in hardness between the two positions also being rather small.

FIG. 8—STRUCTURE OF RAIL AT POSITION 5 IN FIG. 1, × 500

FIG. 9—STRUCTURE OF RAIL AT POSITION 6 IN FIG. 1, × 500

FIG. 7—STRUCTURE OF RAIL AT POSITION 6 IN FIG. 1, × 100

FIG. 9—STRUCTURE OF RAIL AT POSITION 6 IN FIG. 1, × 500

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 30
to
Members of Executive Committee
Committee on Welded Rail Joints
on

Results of Shearing Tests

of

Small Preheated and Postheated Welded Specimens

Progress Report No. 26 outlined a program for shearing tests of small welded specimens, which were to be preheated or post heated. Progress Report No. 28 gave a further explanation of the purpose of these tests. This Progress Report No. 30 gives the results that have been obtained on a part of the program.

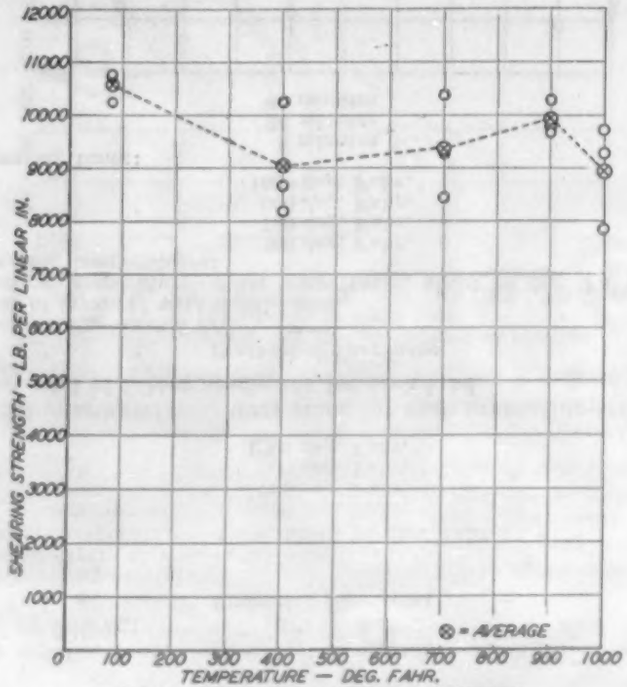


FIG. 1. LOW CARBON ANGLES — PREHEATED

The specimens which have been welded and tested were all welded with the metal electrode process with one layer of weld metal and only that part of the postheating program has been carried out for which the "preheating temperature" was room temperature.

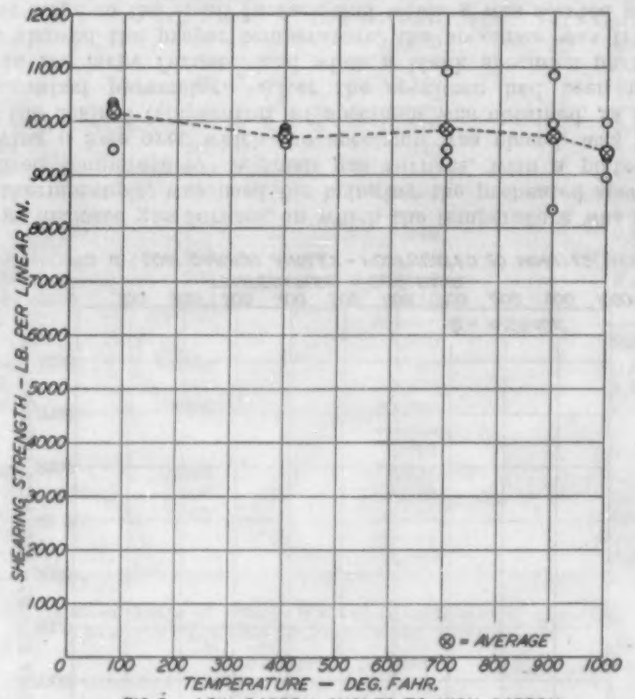


FIG 2 LOW CARBON ANGLES TO HIGH CARBON RAILS - PREHEATED

The shape of the specimens is shown in Bureau of Standards drawing Fig. 1, which was included with Progress Report No. 28.

Two series of specimens were made. One series was made by welding two low carbon steel angles together, as shown in Fig. 1, Progress Report No. 28. This series will be referred to as "Low Carbon Angles to Low Carbon Angles." In the other series, the narrow angle—2½ inches wide—was replaced by a portion of an 85 lb. per yd. T-rail, from which the head had been cut. The web of the T-rail was welded to the wider angle and these specimens will be referred to as "Low Carbon Angles to High Carbon Rails."

The carbon content and Brinell hardness numbers (3000 Kg. load ball 1 cm. in diameter) are as follows:

	Carbon content per cent	Brinell No.
Angle	0.23	132
Rail	0.59	234

These results, then, deal with the shearing strength of specimens prepared as follows:

Preheated Specimens

Type of welding—metal arc.
Number of layers of weld metal—one.
Preheating temperatures—room, about 80 deg. Fahr.
400 deg. Fahr.
700 deg. Fahr.
900 deg. Fahr.
1000 deg. Fahr.

Three similar specimens were made for each preheating temperature making a total of fifteen specimens for each kind.

Postheated Specimens

Type of welding—metal arc.
Number of layers of weld metal—one.
Preheating temperature—room temperature, about 80 deg. Fahr.
Postheating temperatures:
400 deg. Fahr.
700 deg. Fahr.
900 deg. Fahr.
1000 deg. Fahr.

Postheating times:
5 minutes
20 minutes
60 minutes

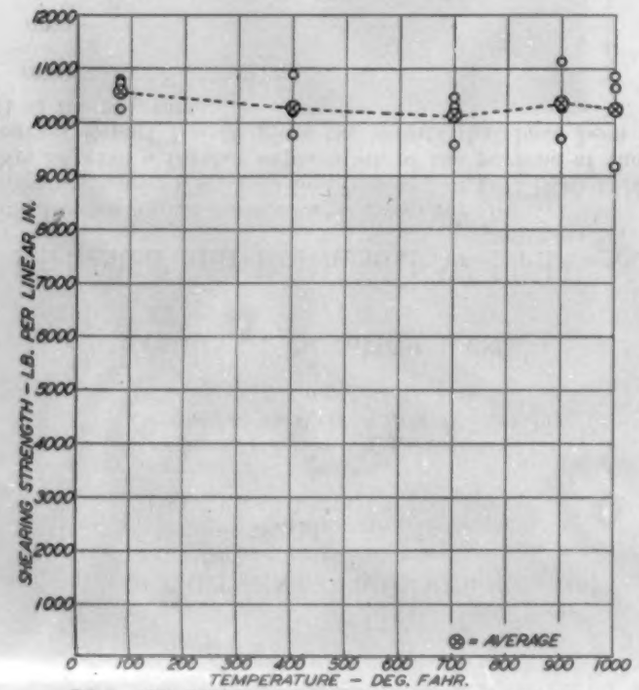


FIG 3 LOW CARBON ANGLES – POSTHEATED 5 MINUTES

Three similar specimens were made for each post-heating temperature and time, making a total of thirty-six specimens for each kind.

The welding was done by an employee of the Capital Traction Company, without expense to the Committee. A Rail Welding and Bonding Welding machine and 5/32 inch diameter Roebling welding rod were used.

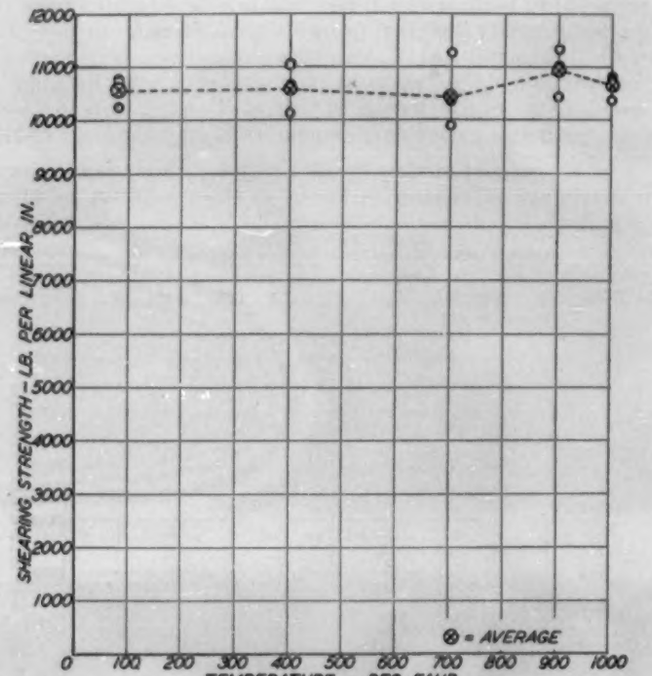


FIG 4 LOW CARBON ANGLES – POSTHEATED 20 MINUTES

A large enclosed gas furnace, in which the temperature was measured with a thermocouple, was used for bringing the preheated specimens to the desired temperature. A small gas furnace, with a plate over its top, having a hole over which the specimen was placed, was regulated so that the desired temperature of specimen was obtained, as measured by the contact pyrometer. After the specimen had been uniformly heated in the large furnace, and when a blank specimen on the small furnace showed the proper temperature, the specimen was transferred from the large to the small furnace and welding was started as soon as the contact pyrometer showed the desired temperature reading on the specimen.

This method of heating was used because the large furnace gave a fairly uniform temperature to the entire specimen. It was, however, impossible to weld the specimens inside this furnace and they were therefore placed for welding on the smaller furnace on which they could be

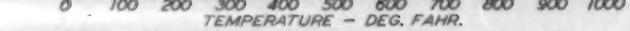


FIG 3 LOW CARBON ANGLES - POSTHEATED 5 MINUTES

impossible to weld the specimens inside this furnace and they were therefore placed for welding on the smaller furnace on which they could be

welded in a short time but for which the heat distribution in the specimen was less uniform.

The postheated specimens were welded at room temperatures and immediately put in the large furnace and left for the required period of time.

The welds were about 2 inches long and were then milled down to a

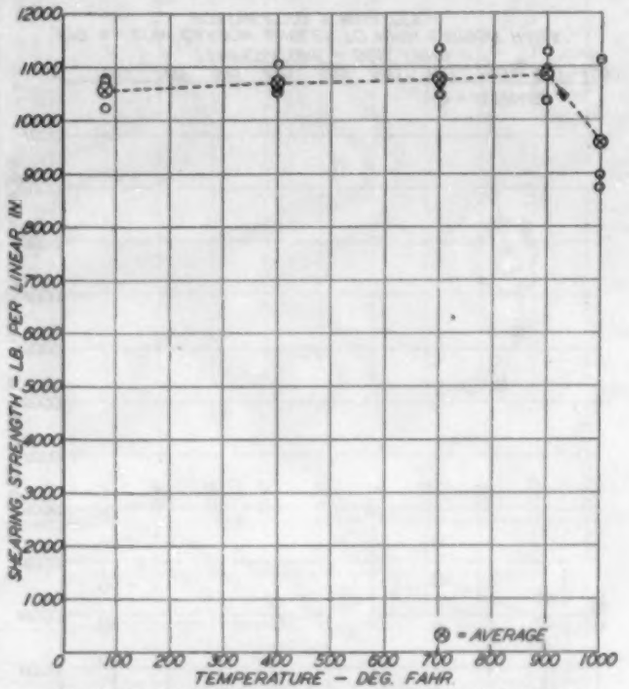


FIG. 5. LOW CARBON ANGLES - POSTHEATED 60 MINUTES

length of 1 inch. This removed all craters and left a definite length of weld metal. The cross-section of the welds varied somewhat from specimen to specimen and averaged about $\frac{3}{8}$ inch on each leg of the fillet weld.

The specimens were tested in compression, causing shearing stresses in the welds by loading in a 50,000 lb. capacity testing machine, having a spherical bearing attached to the moving head. They were carefully centered under the spherical bearing. The maximum load was divided by the sum of the measured lengths of the welds to obtain the shearing strength in pounds per linear inch.

The results of the tests are given in Tables 1 and 2. The individual and average values have been plotted in Figures 1-8. In Figures 3-8, for the post-heated specimens, the values for the specimens MIR-a, b, c, of the preheating series, have also been shown since essentially they

TABLE 1—Results of Tests of Small Welded Specimens—Preheated, Shearing Strength of Welds in Pounds per Linear Inch

Specimen	Preheated deg. Fahr.	Low Carbon Angles to Low Carbon Angles	Low Carbon Angles to High Carbon Rails
M1—Ra	80	10,250	9,460
M1—Rb	80	10,720	10,830
M1—Rc	80	10,750	10,210
Average		10,570	10,170
M1—4a	400	8,680	9,750
M1—4b	400	10,240	9,590
M1—4c	400	8,190	9,800
Average		9,040	9,710
M1—7a	700	9,280	10,930
M1—7b	700	10,380	9,490
M1—7c	700	8,450	9,210
Average		9,370	9,880
M1—9a	900	9,780	10,880
M1—9b	900	9,670	8,310
M1—9c	900	10,280	9,920
Average		9,910	9,700
M1—10a	1,000	7,830	9,960
M1—10b	1,000	9,280	8,930
M1—10c	1,000	9,710	9,300
Average		8,940	9,400

TABLE 2—Results of Tests of Small Welded Specimens—Postheated, Shearing Strength of Welds in Pounds per Linear Inch

Specimen	Postheated deg. Fahr.	Low Carbon Angles to Low Carbon Angles			Low Carbon Angles to High Carbon Rails		
		5 min.	20 min.	60 min.	5 min.	20 min.	60 min.
M1R—4a	400	10,220	11,040	11,040	10,070	10,020	6,640
M1R—4b	400	9,760	10,110	10,450	10,630	9,890	8,080
M1R—4c	400	10,900	10,640	10,620	9,780	9,430	10,170
Average		10,290	10,600	10,700	10,160	9,780	8,300
M1R—7a	700	10,290	11,250	10,590	8,620	10,890	11,670
M1R—7b	700	9,560	10,290	11,330	10,210	10,020	9,740
M1R—7c	700	10,470	9,900	10,460	9,260	9,380	10,020
Average		10,110	10,480	10,790	9,360	10,100	10,480
M1R—9a	900	10,300	10,440	11,300	10,600	10,840	10,450
M1R—9b	900	11,130	11,330	10,360	9,660	10,280	10,530
M1R—9c	900	9,710	10,980	10,930	10,080	10,420	9,020
Average		10,380	10,920	10,860	10,110	10,510	10,000
M1R—10a	1,000	10,860	10,810	11,120	9,760	10,190	9,320
M1R—10b	1,000	9,170	10,830	8,970	10,230	9,320	11,060
M1R—10c	1,000	10,670	10,370	8,720	9,610	10,000	9,070
Average		10,230	10,670	9,600	9,870	9,840	9,820

belong to both groups of tests. Figures 9 and 10 show the average values only and afford an opportunity for comparing the various groups of specimens.

In nearly all groups, the shearing strength values are remarkably uniform for tests of this kind. The preheating tests show that the higher temperatures do not result in weld metal having a greater strength than for room temperature, or no preheating. The variation of average strength with temperature is, however, small over the entire range of temperatures. The welder remarked that it seemed easier to make the metal "weld in" for the preheated specimens but evidently the strength of the weld metal was not increased on this account.

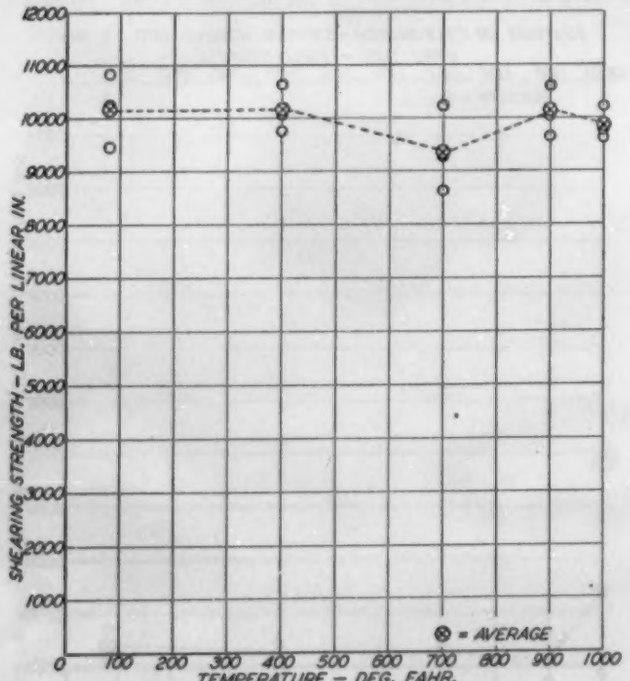


FIG. 6. LOW CARBON ANGLES TO HIGH CARBON RAILS POSTHEATED 5 MINUTES

With the postheated specimens having low carbon angles welded together, Fig. 10 shows that there is a slight tendency for increase in strength with increase of post-heating time but this is not consistently true for the specimens of low carbon angles welded to high carbon rails.

Reference to Tables 1 and 2 shows, that in general, the range in strength values for the individual specimens is about the same from group to group. In some cases, as notably in the group of low carbon angles to high carbon rails, post-heated for 60 minutes at 400 deg. Fahr., Table 2 shows that specimen c had a strength of 10,170 lb. per

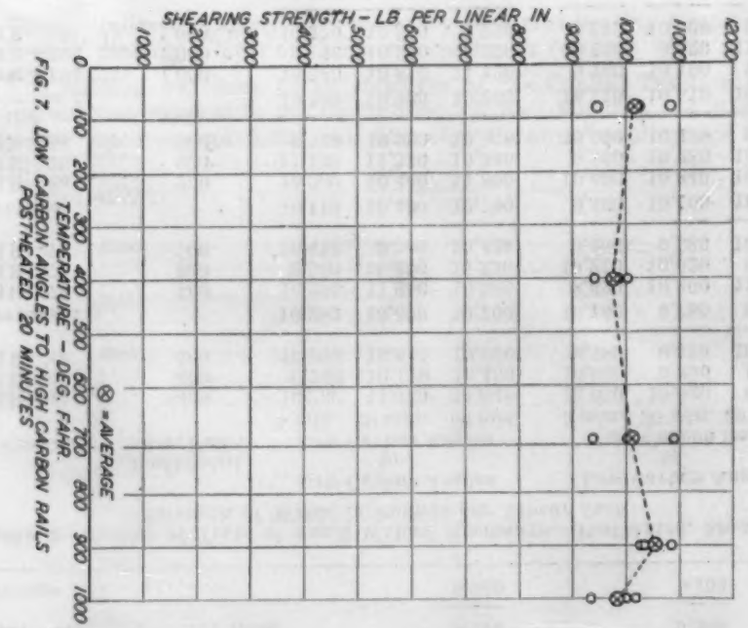


FIG. 7. LOW CARBON ANGLES TO HIGH CARBON RAILS POSTHEATED 20 MINUTES

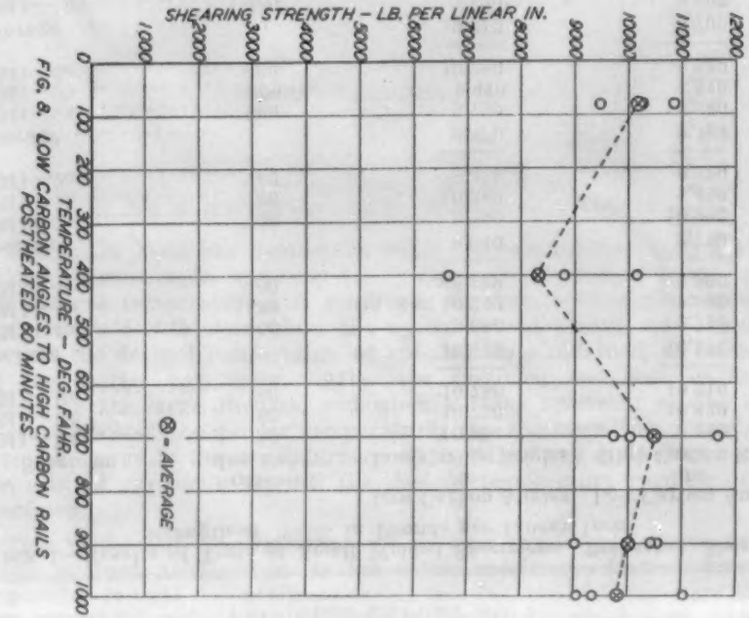


FIG. 8. LOW CARBON ANGLES TO HIGH CARBON RAILS POSTHEATED 60 MINUTES

angles to high carbon rails, post-heated for 60 minutes at 400 deg. Fahr., Table 2 shows that specimen c had a strength of 10,170 lb. per

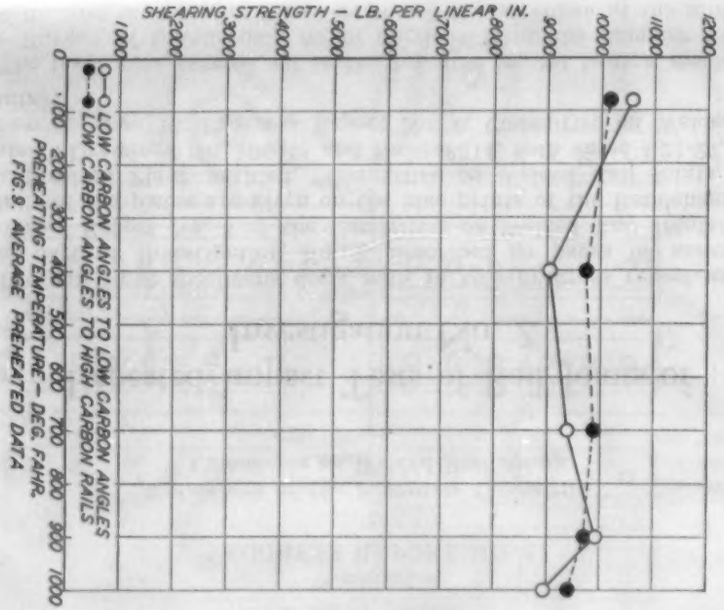

SHEARING STRENGTH — LB. PER LINEAR IN.
1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000
0
100 200 300 400 500 600 700 800 900 1000
LOW CARBON ANGLES TO LOW CARBON ANGLES
LOW CARBON ANGLES TO HIGH CARBON RAILS
PREHEATING TEMPERATURE — DEG. FAHR.

FIG. 9. AVERAGE PREHEATED DATA

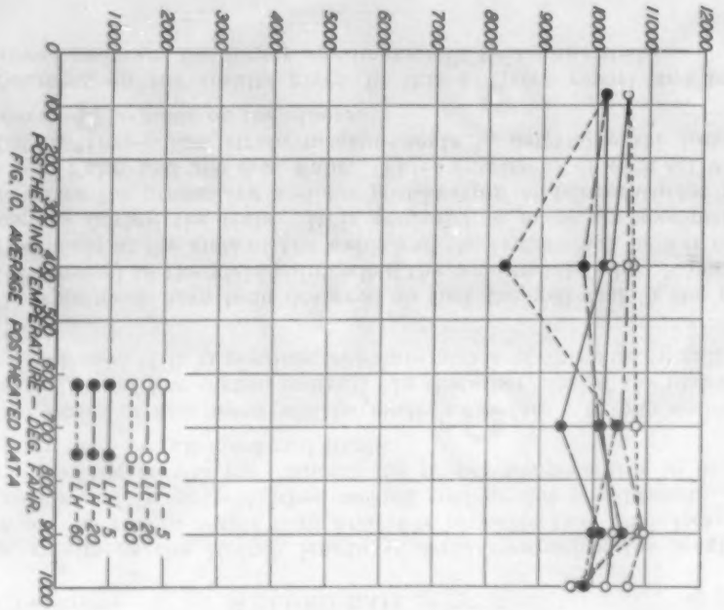


FIG. 10. AVERAGE POSTHEATED DATA

sq. in. and the average was lowered by the other two specimens. The low average value, in this case, is therefore due more to relatively poor welding than to the real temperature effect.

These specimens were designed so that the weakest part would be the weld metal and were so short that locked-up stresses had little effect on it. The tests show that the temperatures used had relatively little

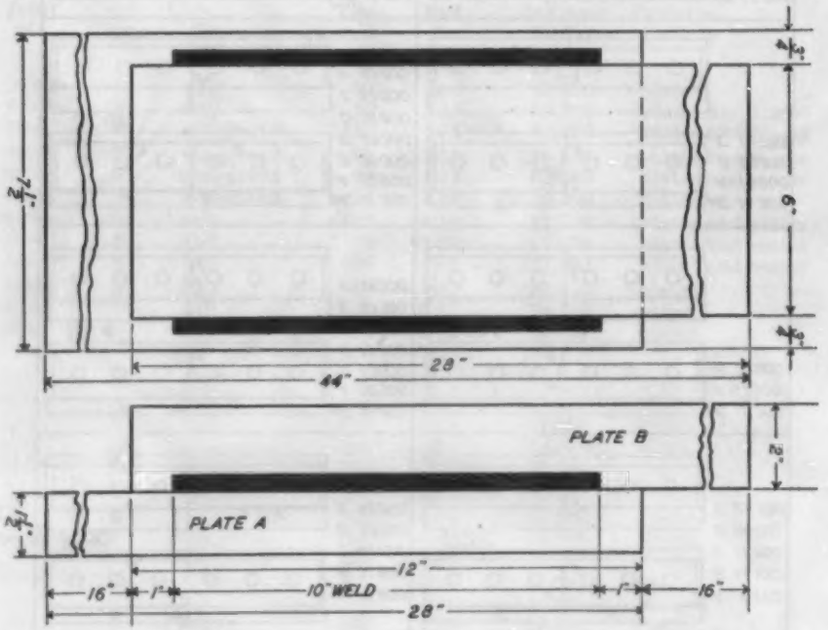


FIG. 11—PROPOSED TENSILE SPECIMEN FOR PREHEATED AND POSTHEATED WELDED SEAMS

effect on the shearing strength of the weld metal when the welded parts were relatively free from stress. The value of preheating or post-heating, must therefore lie in the relief or elimination of stress in the adjacent material produced by the high, concentrated temperatures of the arc.

If then, these tests show that the quality of the weld metal itself is not affected by temperatures up to 1000 deg. Fahr., it is recommended that the remainder of the program outlined in Progess Report No. 26 be omitted. The temperature of 1000 deg. Fahr. did not produce a red color when the specimen was in daylight but showed a faint color in the enclosed oven.

New Program

In order to investigate the effect of preheating and of postheating on the strength of the weld metal when locked-up stresses are present, it is proposed to make up specimens of the form shown in Fig. 11. In

these specimens the 10-inch length of weld approaches the length of seam on one rail of a rail joint and it is probable that some locked up stresses would be present when welded cold or not post-heated. It is hoped that the results will indicate the proper temperatures to be used for later tests of full sized rail joints.

Two series of specimens will be made, as before. In one series the plates will be of low carbon content. In the other, one of the plates will be of rail steel if it is possible to obtain plates of this size in rail steel material.

The specimens have been designed so that the material in the plates is not stressed to the yield point when the weld metal fails. No cutting will be made at the ends of the welds and the craters will be left on the specimens during the tests. It is proposed to make six specimens of each series for preheating and for post-heating at temperatures: room, 400 deg. Fahr. and 900 deg. Fahr. Three specimens of each set will be tested in tension and strain measurements to determine the locked-up stresses will be made on the others.

Comment on the results given in this progress report and on the proposed program for larger specimens will be appreciated.

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 31
to
Members of the Executive Committee
Committee on Welded Rail Joints
on

Repeated Impact Tests of Rail Joints of Investigation No. 2

The rail joint specimens dealt with in this progress report are the final part of Investigation No. 2, described on pages 66 and 67 of Progress Report No. 3 of the Committee on Welded Rail Joints. The details of the plates are given on the blue prints of the Bethlehem Steel Co., Steelton Plant, entitled, "Committee on Welded Rail Joints, Joint Plates," Drawings No. 136448 and No. 148314, both dated 4-21-27, (also shown on page 18, Progress Report No. 6, Committee on Welded Rail Joints).

The tests were carried out in the repeated impact testing machine at the Bureau of Standards. As in previous tests, the hammer weighed 400 lb., and in dropping 6 inches, struck the specimen at the middle of the 22-in. span. The hammer struck one of the rails 2 in. from the ends of the rails which were in contact at the joint. The approximate number

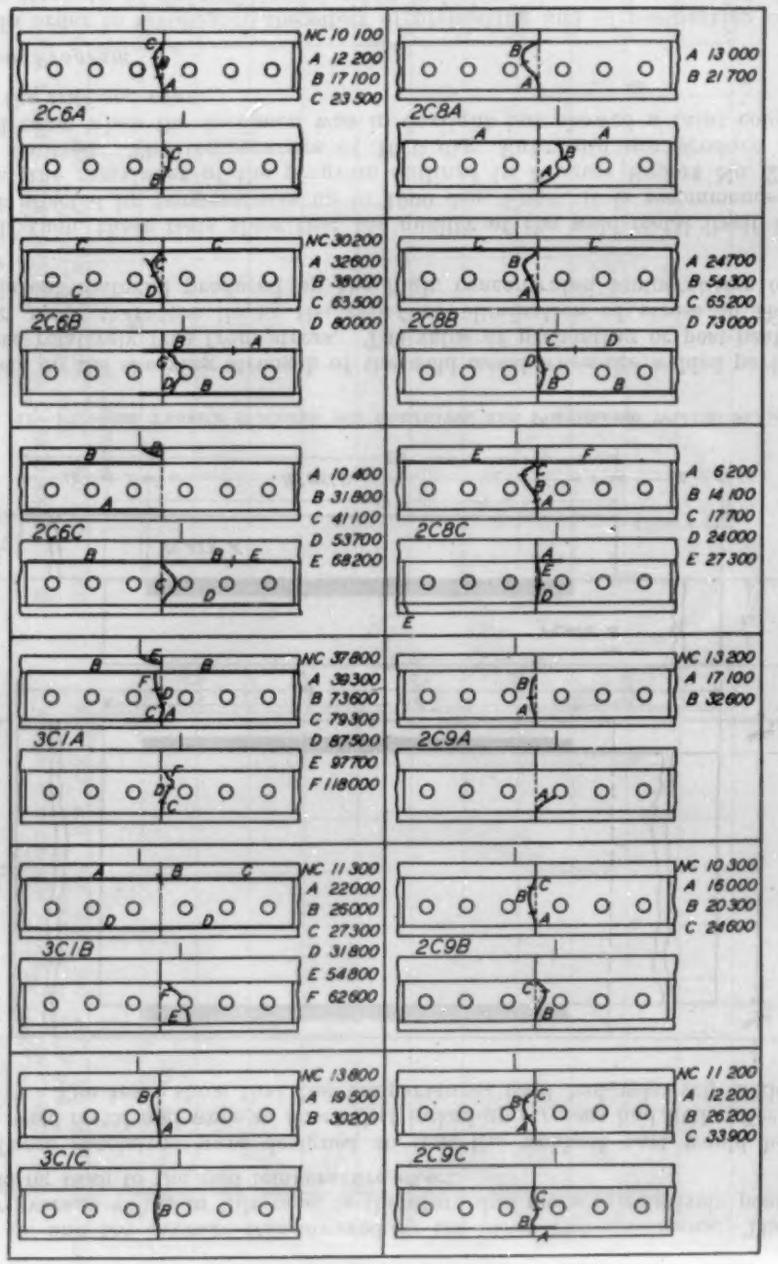


FIG. 1—FAILURE CHART. REPEATED IMPACT TESTS, RAIL JOINTS. CARBON ARC

the 22-in. span. The hammer struck one of the rails 2 in. from the ends of the rails which were in contact at the joint. The approximate number

FIG. 1—FAILURE CHART. REPEATED IMPACT TESTS, RAIL JOINTS. CARBON ARC

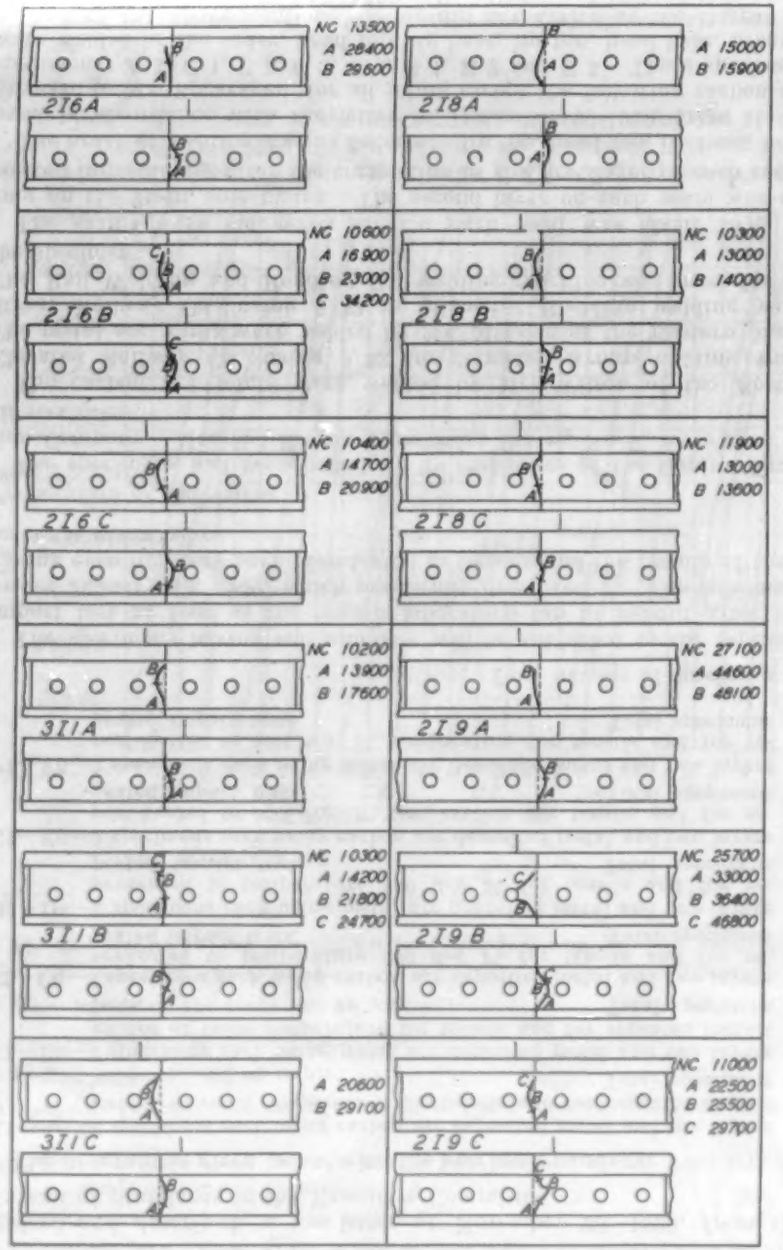


FIG. 2—FAILURE CHART. REPEATED IMPACT TESTS, RAIL JOINTS. METAL ARC

of blows per minute was 78. The total number of blows to cause failure are given in Table 1.

TABLE 1—Results of Repeated Impact Tests of Rail Joints of Investigation No. 2

Joint No.	Plate	Seams	Time min.	Welding Rod lb.	No. of Blows to Cause Failure	Location of Principal Failure
		Carbon arc, hand feed, two layers				
2C6A	6	full	94	3.84	23,500	plates
2C6B	6	full	90	3.88	80,000	plates and seams
2C6C	6	staggered	105	4.54	68,200	plates and seams
3C1A	7	staggered	61	2.53	118,000	plates and seams
3C1B	7	staggered	60	3.04	62,600	plates and seams
3C1C	7	staggered	74	2.69	30,200	plates
2C8A	8	full	102	4.16	21,700	plates and seams
2C8B	8	full	78	4.28	73,000	plates and seams
2C8C	8	full	106	4.08	27,300	plates and seams
2C9A	9	full	81	3.81	32,600	plates
2C9B	9	full	78	3.91	29,600	plates
2C9C	9	full	83	3.92	33,900	plates
		Metal arc, two layers				
2I6A	6	full	...	...	29,600	plates
2I6B	6	full	116	4.58	34,200	plates
2I6C	6	full	112	4.58	20,900	plates
3I1A	7	staggered	107	4.50	17,600	plates
3I1B	7	staggered	110	4.40	24,700	plates
3I1C	7	staggered	112	4.33	29,100	plates
2I8A	8	staggered	121	5.20	15,900	plates
2I8B	8	staggered	107	4.92	14,000	plates
2I8C	8	staggered	125	5.38	13,600	plates
2I9A	9	full	97	4.48	48,100	plates
2I9B	9	full	107	4.21	46,800	plates
2I9C	9	full	105	4.20	29,700	plates

Failure charts for these joints are shown on Figs. 1 and 2. For each joint, the head side is shown above the lip side. The number of blows at the last observation for which no cracks were observed is given on these charts.

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
PROGRESS REPORT NO. 32
to
Members of the Executive Committee
Committee on Welded Rail Joints

Tensile Tests of Preheated and Post-heated Welded Rail Joints of Investigation No. 3 Revised

The welded rail joints dealt with in this report represent the tensile specimens of the "Preheating and Post-heating Investigation No. 3" as

revised and described in the letter of November 23, 1929, from the Bureau of Standards to the Executive Committee.

The program is given below with the specimen numbers.

A1—A6—3 specimens each using carbon arc deposited metal and two layers *welded at room temperature* for tensile and for repeated impact tests. Total specimens 6

B1—B6—3 specimens each using metal arc deposited metal and two layers *welded at room temperature* for tensile and for repeated impact tests. Total specimens 6

C1—C6—3 specimens each using carbon arc deposited metal and two layers *preheated* to temperature *900 deg F.* for tensile and for repeated impact tests. Total specimens 6

D1—D6—3 specimens each using metal arc deposited metal and two layers *preheated* to temperature *900 deg F.* for tensile and for repeated impact tests. Total specimens 6

E1—E6—3 specimens each using carbon arc deposited metal and two layers *post-heated to 900 deg. F.* temperature for tensile and for repeated impact tests. Total specimens 6

F1—F6—3 specimens each using metal arc deposited metal and two layers *post-heated to 900 deg. F.* temperature for tensile and for repeated impact tests. Total specimens 6

Total number of specimens 36

The specimens having odd numbers will be subjected to the repeated impact test as soon as the impact laboratory can be rebuilt after the fire of January 14, 1930, which practically destroyed it. The specimens having even numbers have been tested in tension and the results of these tests are given below.

Preparation of Specimens

The specimens had been bolted up by employees of the Capital Traction Company. Modified Boston Type Joint Plates, No. 7, were used on all specimens.

The carbon arc joints were welded by Mr. Wilson of the Boston Elevated Railway Co., using 9/32 in. diameter Armco welding wire. The metal arc joints were welded by Mr. McLean of the Eastern Mass. Street Railway Co., using 5/32 in. diameter Roebling welding wire. The Rail Welding and Bonding Co. welding machine was used for all the specimens.

The seams were staggered so that each weld was about 23½ in. long on the 26-in. side plates. The second layer on each seam was deposited immediately after the completion of the first layer of each seam.

The order of welding was as follows:—lip top, head top, lip base, head base, in accordance with the letter of December 9, 1929, from H. M. Steward to Mr. Spraragen, for all joints except the following carbon arc specimens: A 1, C 1, C 2, C 3, C 4, E 1, E 2 and E 3. These specimens were welded in the order, head top, lip base, lip top, head base, because a copy of the above-mentioned letter did not arrive at the Bureau of Standards until December 16, 1929, after the completion of these last-mentioned specimens.

Furnace and Temperature Measurements for Preheated and Post-Heated Specimens

These specimens were heated in a gas-fired manually controlled brick furnace of the Ceramic Division. The temperatures were measured with alumel-chromel thermocouple, welded, unprotected, junctions and it is believed that the temperatures were all at 900 deg. Fahr. ± 15 deg.

Preheated Specimens

The joints were put in the furnace and brought to a temperature of 900 deg. Fahr., then withdrawn and the first seam was immediately started. After the completion of the seam, the specimen was again put in the furnace and brought to the desired temperature, thus being in the

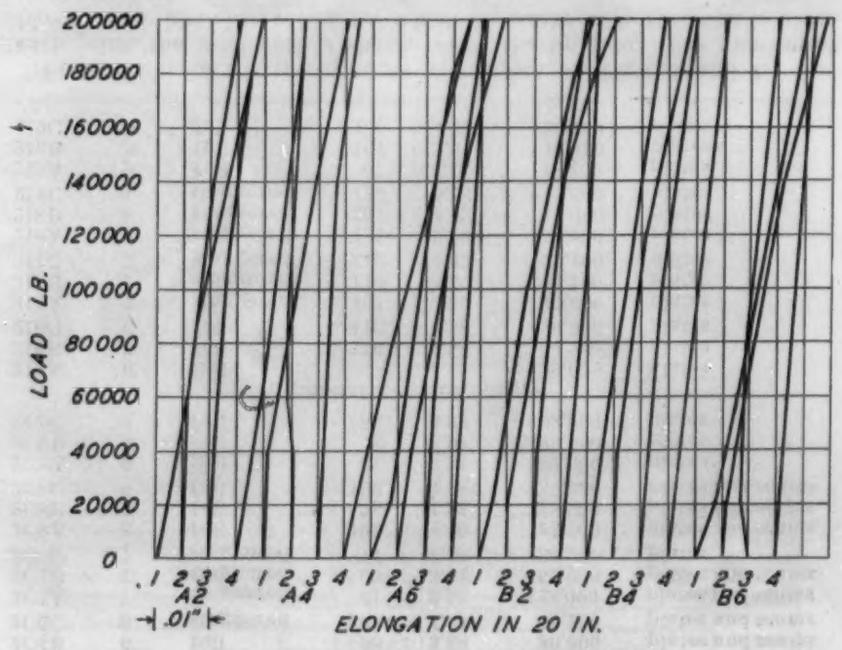


FIG. 1—SPECIMENS WELDED AT ROOM TEMPERATURE

furnace four times. After the completion of the last seam, it was set on fire bricks until it had cooled to room temperature.

Post-heated Specimens

These were completely welded at room temperature and then put in the furnace, brought to 900 deg. Fahr., held for 20 min., withdrawn and placed on fire bricks to cool. It usually took about 1½ hr. to bring these

a copy of the above-mentioned letter did not arrive at the Bureau of Standards until December 16, 1929, after the completion of these last-mentioned specimens.

These were completely welded at room temperature and then put in the furnace, brought to 900 deg. Fahr., held for 20 min., withdrawn and placed on fire bricks to cool. It usually took about 1½ hr. to bring these

specimens to the required temperature after they were placed in the furnace.

Tensile Tests

The joints were tested in the large Emery machine, using the special holding fixtures furnished by the Lorain Steel Company. Strain measurements were taken on four 20-in. gage lengths with Howard gages.

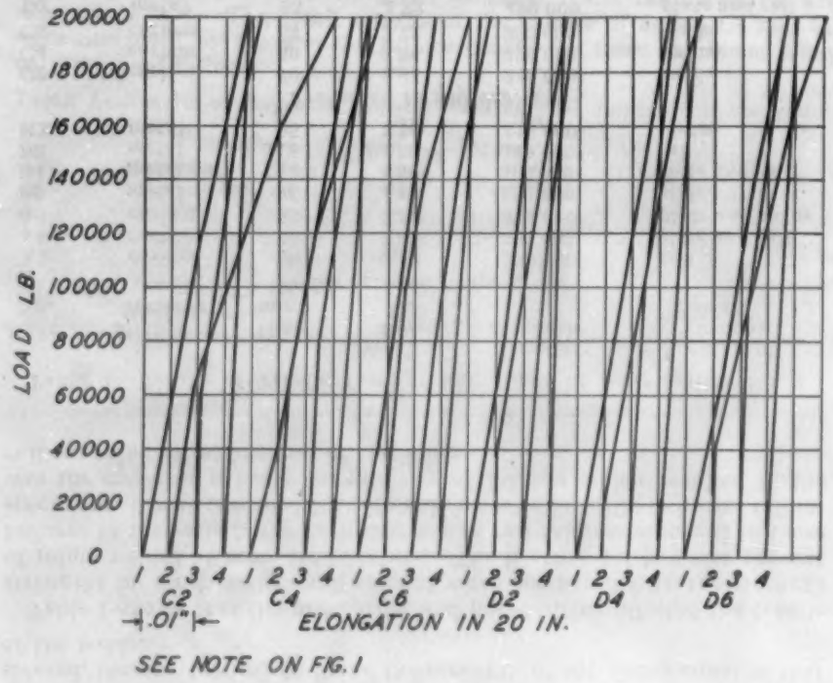


FIG. 2—PREHEATED SPECIMENS

The load-strain curves are shown in Figs. 1, 2 and 3. The results of the tests are given in Table 1.

The details of the tests are as follows:

Specimens Welded at Room Temperature

A2—Rail broke at end of welds.

A4—Lip side plate broke through middle bolt hole and the rail broke at ends of welds.

A6—Lip side plate broke through middle bolt hole and on the head side the welds on one rail sheared.

B2—Both plates broke at middle bolt hole.

B4—Lip side plate broke through middle bolt hole and cracked base of rail. One rail then broke at end of welds.

B6—One rail broke at ends of welds.

BX—Both plates broke at middle bolt holes.

Specimens Preheated

C2—Welds on one rail all sheared.

C4—Lip side welds on one rail, and head side welds on the other rail sheared.

C6—Lip side welds on one rail and head side welds on the other rail sheared.

D2—Plate on lip side broke at joint, then one rail broke at end of plates.

D4—The lip side plate broke through middle bolt hole and one rail broke at end of welds through the third hole in the rail web from joint.

D6—Lip side plate broke at joint. Welds on one rail sheared on head side.

Specimens Postheated

E2—Both plates broke at middle bolt hole.

E4—Both plates broke at middle bolt hole.

E6—Lip side plate broke at middle bolt hole and head side welds on one rail sheared.

F2—Both pates broke at middle bolt hole.

F4—All welds on one rail sheared.

F6—Plate on lip side broke through middle bolt hole and plate on head side broke at the joint.

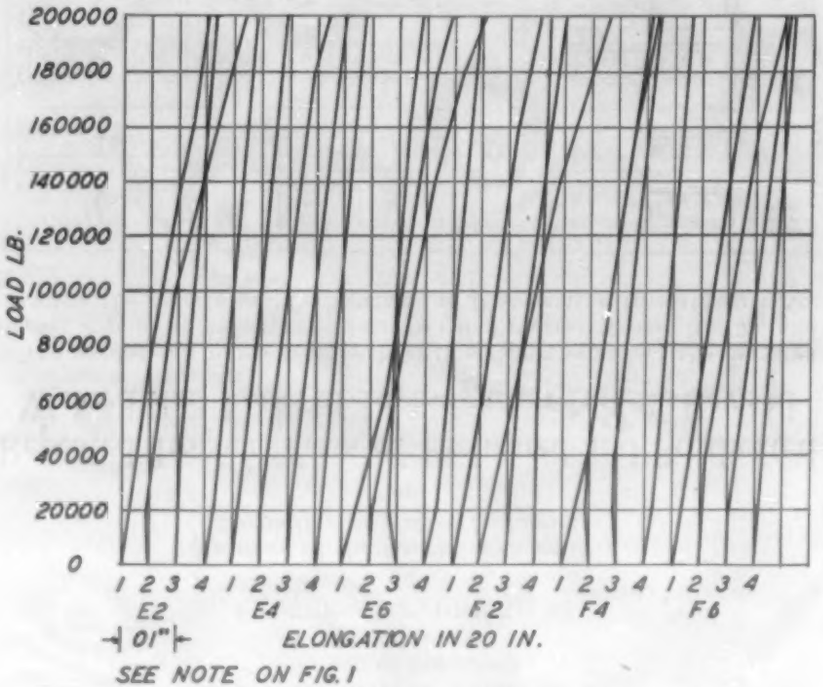


FIG. 3—POSTHEATED SPECIMENS

The specimen BX, welded with metal arc at room temperature, was suggested by members of the Bureau staff. The lengths of the welds of this specimen were such that their centroid coincided with the centroid of the rail section. These lengths were:

Lip top seam	25.0 + ½ in.
Head top seam	23.3 + ½ in.
Each base seam	11.7 + ½ in.

The extra half inch lengths were added for allowance of poorer weld at ends. Table 1 shows that this joint, having only half length base seams, did not break in the welds and withstood a greater load than any of the other specimens welded at room temperature with the metal arc.

The quality of all of the welds given in this report was judged to be excellent. Many failures occurred through the middle bolt holes of the side plates, and it is suggested that the omission of these holes be considered, thereby tending to bring the strength of the plates equal to that of the welds.

Table 1 shows that the preheating and post-heating affected the tensile strengths by a relatively small amount when compared with the strength of joints welded at room temperature. The heating did however prevent failures in the rails for in each case where rail failures occurred in these specimens, it was preceded by a lip side plate failure. This initial failure was the cause of a heavy eccentricity of loading which resulted in the rail snapping off at the end of the welds.

TABLE 1—Results of Tensile Tests of Rail Joints of Investigation No. 3

Joint No.	Method of Welding	Time min.	Welding Rod lb.	Tensile Strength lb.	Location of Principal Failure
		Welded at room temperature			
A2	carbon	56	3.23	359,000	rail
A4	carbon	46	3.08	399,000	plate and rail
A6	carbon	52	3.22	419,000	plate and welds
B2	metal	96	4.19	394,000	plates
B4	metal	114	4.59	405,000	plate and rail
B6	metal	118	4.59	349,000	rail
BX	metal	95	3.70	413,000	plates
		Preheated to 900 deg. F.			
C2	carbon	70	2.85	349,000	welds
C4	carbon	59	2.36	328,000	welds
C6	carbon	53	2.72	393,000	welds
D2	metal	93	4.22	499,000	plate and rail
D4	metal	104	4.36	404,000	plate and rail
D6	metal	108	4.37	462,000	plate and welds
		Post-heated at 900 deg. F. for 20 min.			
E2	carbon	59	3.04	436,000	plates
E4	carbon	62	3.16	424,000	plates
E6	carbon	51	3.06	460,000	plate and welds
F2	metal	89	3.97	467,000	plates
F4	metal	106	4.60	419,000	welds
F6	metal	122	4.96	390,000	plates

DEPARTMENT OF COMMERCE
Bureau of Standards
Washington
PROGRESS REPORT NO. 33
to
Members of the Executive Committee
Committee on Welded Rail Joints
on

Repeated Impact Tests of Preheated and Postheated Welded Rail Joints of Investigation No. 3, Revised

The welded rail joints dealt with in this report represent the repeated impact specimens which were described in Progress Report No. 32, and complete the reports on "Preheating and Post-heating Investigation No. 3."

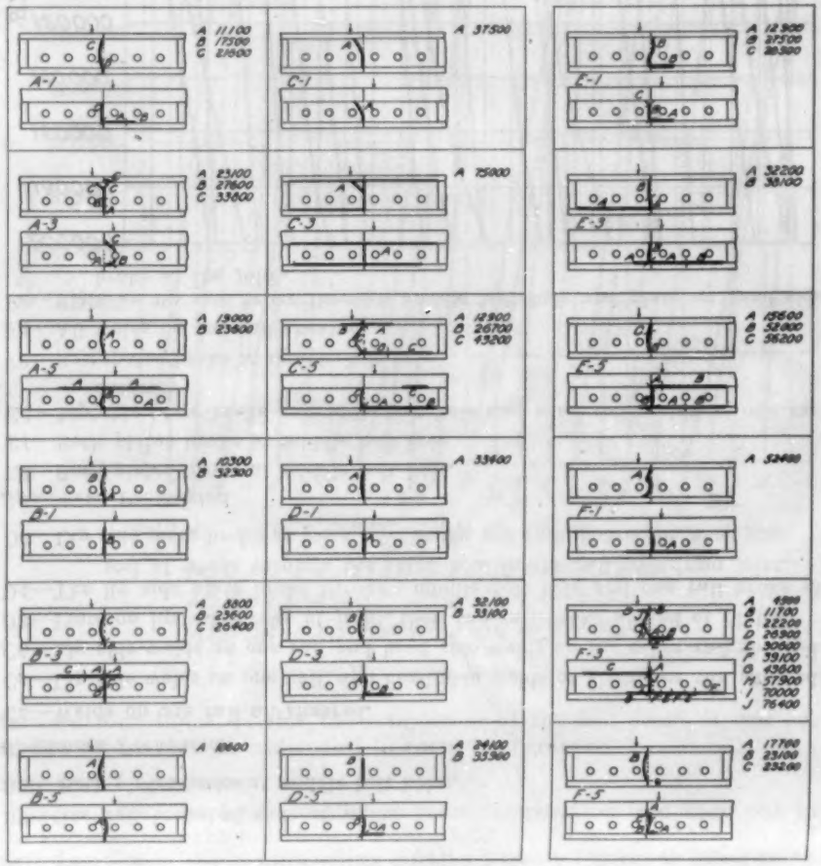


FIG. 1—RESULTS OF REPEATED IMPACT TESTS

F4	metal	106	4.36	$12,000	welds
F6	metal	122	4.96	390,000	plates

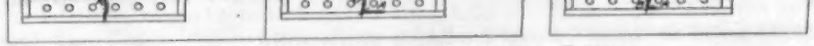


FIG. 1—RESULTS OF REPEATED IMPACT TESTS

The tests were carried out in the repeated impact testing machine of the Bureau of Standards. As in previous tests, the hammer weighed 400 lb., and in dropping 6 in., struck the specimen at the middle of the 22-in. span. The hammer struck one of the rails 2 in. from the ends of the rails which were in contact at the joint. The approximate number of blows per minute was 85. All bolts had been removed previous to the test.

The results of the tests are given in Table 1 and failure charts are shown in Fig. 1. The detail records of the failure of Joints C1 and C3 were destroyed by fire and the failure charts for these specimens show only the final failure.

TABLE 1—Results of Repeated Impact Tests of Rail Joints of Investigation No. 3

Joint No.	Method of Welding	Time min.	Welding Rod lb.	No. of Blows to Cause Failure	Location at Principal Failure
		Welded at Room Temperature			
A1	carbon	63	3.35	21,600	plates
A3	carbon	49	3.16	33,800	plates
A5	carbon	52	3.06	23,600	plates and seams
B1	metal	106	4.54	32,300	plates
B3	metal	94	4.26	26,400	plates
B5	metal	129	5.11	10,600	plates
		Preheated to 900 Deg. F.			
C1	carbon	68	2.70	37,500	plates
C3	carbon	57	2.68	75,000*	plates and seams
C5	carbon	52	2.72	43,200	plates and seams
D1	metal	73	3.30	33,400	plates
D3	metal	103	4.36	33,100	plates
D5	metal	107	4.39	35,900	plates
		Post-heated to 900 deg. F. for 20 min.			
E1	carbon	75	3.38	28,500	plates
E3	carbon	54	3.04	38,100	plates and seams
E5	carbon	51	3.07	56,200	plates and seams
F1	metal	88	3.98	52,400	plates
F3	metal	99	4.28	76,400	plates and seams
F5	metal	115	4.82	23,200	plates

*The exact number of blows to cause failure is unknown since the data sheet was destroyed by fire, but the number is correct to ±1000 blows.

DEPARTMENT OF COMMERCE
Bureau of Standards
PROGRESS REPORT NO. 34
To Members of the Executive Committee
Committee on Welded Rail Joints

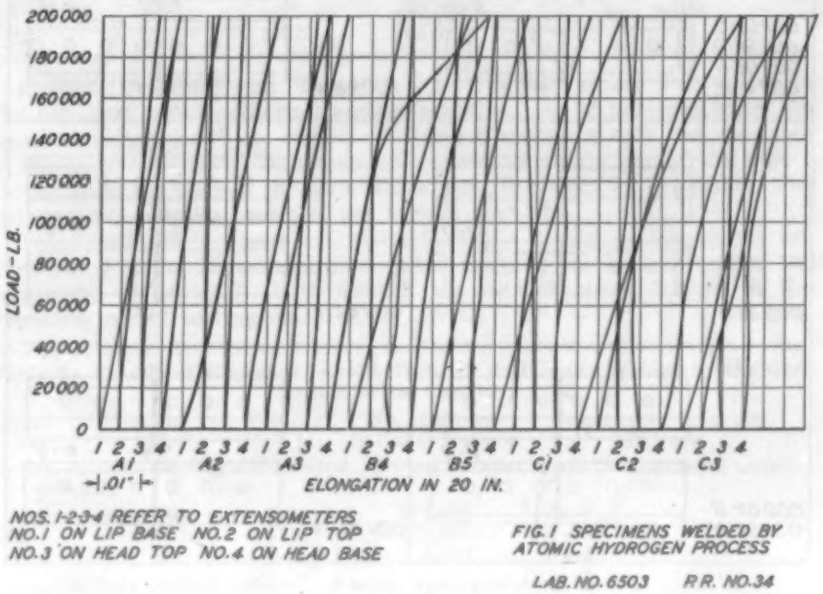
Tensile and Repeated Impact Tests of Rail Joints Welded by The Atomic Hydrogen Process

Seventeen rail joints were welded by the General Electric Company, Schenectady, N. Y. These specimens are divided into three groups characterized by differences in the method of welding, in the design of the welded joint and the position of the joint. All rails were 7″ Finch Trilby rails, 122 lb. per yd., and each piece was 27 inches long.

Group A. These specimens were butt welded by the direct current, metallic electrode, hand arc welding process. The butt ends were chamfered at 45 degrees from both sides to a thickness equalling one-half the original thickness of the section with a hand grinding wheel. Two or three layers of welding were used, and the distance between the butting ends at the start of welding varied as indicated in Table 1, which lists the data taken with reference to the welding of these specimens. These rail joints were placed about 10 inches from the floor, and the joints were not rotated during the process of the welding.

Group B. These specimens were butt welded by the atomic hydrogen process, and the joints were rotated as the weld was made. No description of the preparation of the butting ends was furnished. The welding data are given in Table 1.

Group C. These specimens were welded by the atomic hydrogen process and were of the side plate type, the modified Boston type joint plates,



No. 7, being used. During the welding, the joints were tipped to a maximum angle of 20 degrees to permit more satisfactory welding. The welding data are given in Table 1.

Tensile Tests. Three specimens of groups A and C and two specimens of group B were tested in tension in the large Emery testing machine,

using the special holding fixtures furnished by the Lorain Steel Company. Strain measurements were taken on four 20-inch gage lengths with Howard gages. The load-strain curves are given in Fig. 1. The results of the tensile tests are given in Table 2.

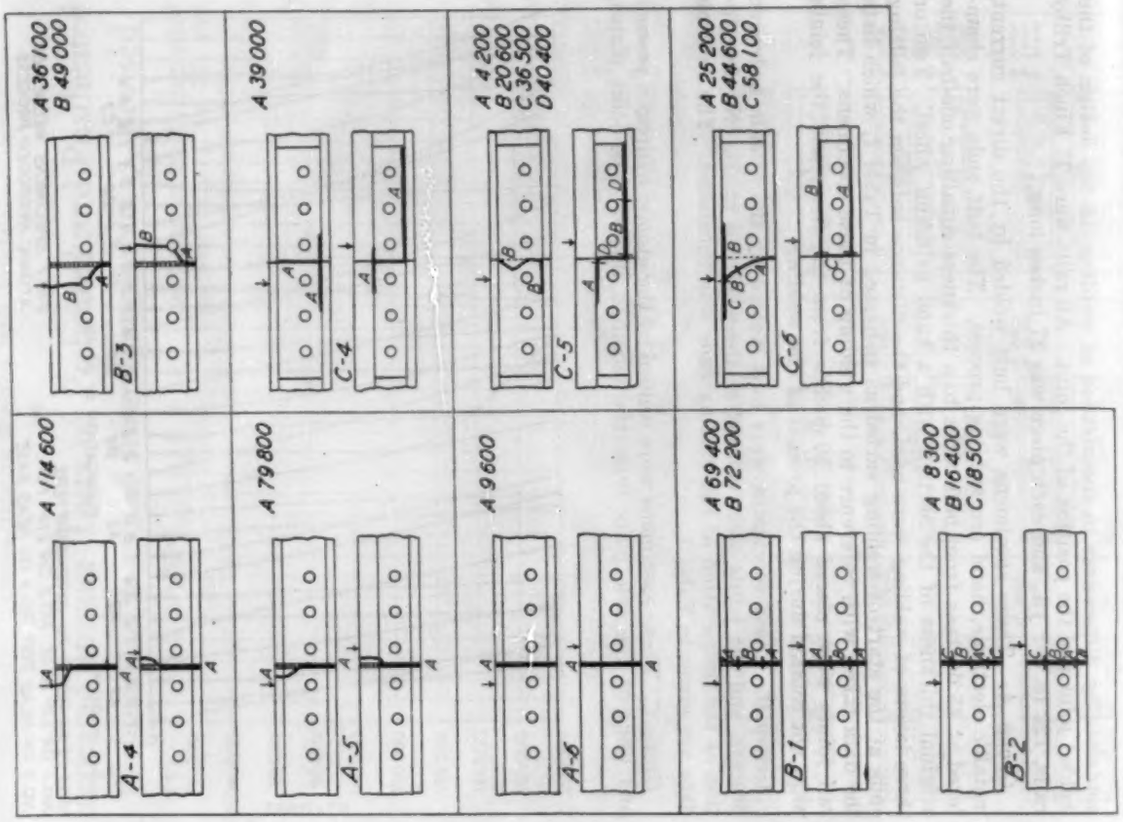


FIG. 2

Table 1—Welding Data for Specimens Welded by the General Electric Company

Specimen No.	Welding Time, Min.	Distance Between Butting Surfaces, In.	No. of Layers	Diameter of Welding Rod: First Layer, In.	Second Layer, In.	Third Layer, In.	Weight of Rod Used, Lb.	Tungsten: Diam., In.	Length, In.	Hydrogen, Cu. Ft.	Energy, Kwh.
Group A, butt welded, not rotated. Direct current, metallic arc, hand welding process.											
A-1	75	3/16	2	5/32	3/16	....	2.25	Not used			2.5
A-2	114	3/16	3	5/32	5/32	5/32	2.61	"	"		3.8
A-3	83	1/4	3	5/32	5/32	3/16	2.74	"	"		3.0
A-4	78	5/16	3	5/32	5/32	3/16	2.81	"	"		2.7
A-5	65¼	5/32	2	5/32	3/16	....	1.92	"	"		1.8
A-6	82	1/4	3	5/32	5/32	5/32	2.16	"	"		2.4
Group B, butt welded, rotated. Atomic hydrogen process.											
B-1	32	Not reported	Not reported		3/16		0.73	1/8	1.6	30	5.1
B-2	29	"	"		3/16		0.81	1/8	1.5	29	4.6
B-3	35	"	"		3/16		0.69	1/8	1.8	33	5.6
B-4	30	"	"		3/16		1.03	1/8	1.5	29	4.8
B-5	33	"	"		3/16		0.95	1/8	1.6	31	5.3
Group C, side plates, rotated not more than 20 degrees. Atomic hydrogen process.											
C-1	118	....	2		3/16		3.12	1/8	5.1	109	16.7
C-2	144	....	3		3/16		3.87	1/8	6.25	132	20.5
C-3	109	....	2		3/16		2.37	1/8	4.75	101	15.4
C-4	88½	....	2		3/16		2.50	1/8	3.87	80	12.5
C-5	99	....	2		3/16		2.69	1/8	4.25	91	14.0
C-6	121	....	2		3/16		2.19	1/8	5.25	111	17.1

Energy, Kwh.									
2.5	3.8	3.0	2.7	1.8	2.4	5.1	4.6	5.6	4.8	5.3	16.7	20.5	15.4	12.5	14.0	17.1

Fig. 2

The details of the tests are as follows:

Group A—butt welded, not rotated.

A-1—The failure was in the weld metal at the butt weld.

A-2—The failure was in the weld metal at the butt weld.

A-3—This rail broke through the weld metal at head and base and through the web of one rail at the extreme edge of the weld metal.

Group B—butt welded, rotated.

B-4—The failure was in the weld metal at the butt weld.

B-5—The failure was in the weld metal at the butt weld.

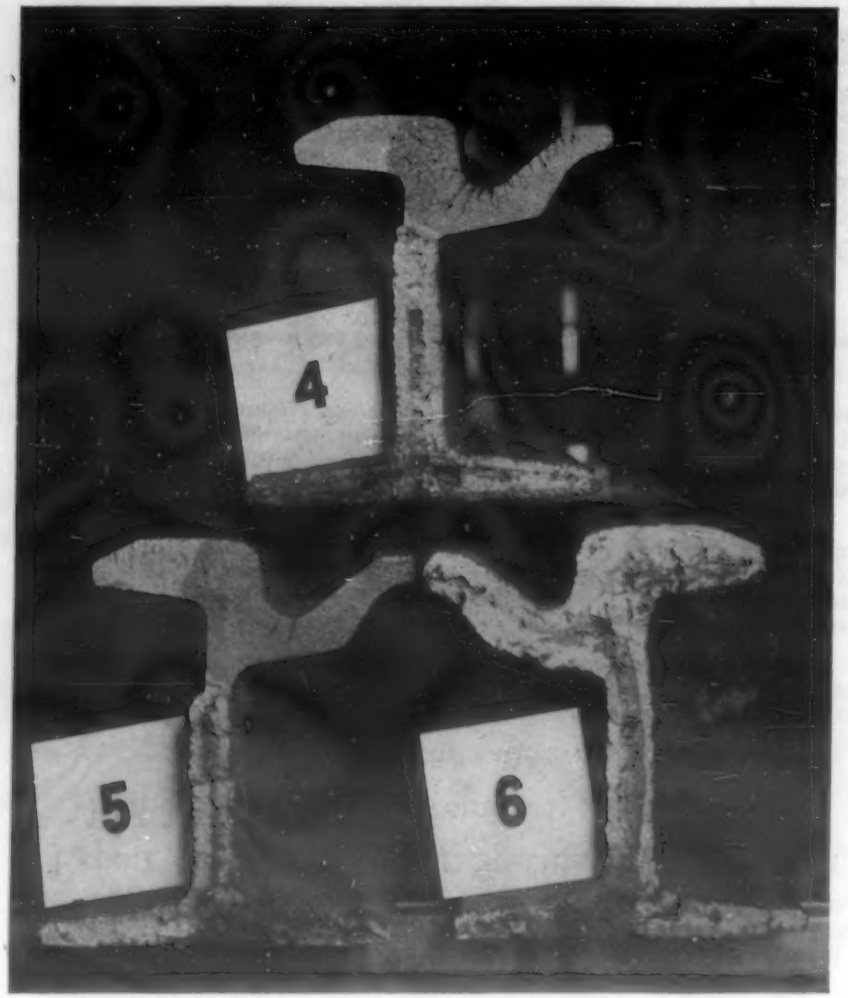


Fig. 3

Group C—side plates welded on.

C-1—On the lip side, the plate broke at the bolt hole nearest the joint. On the head side, the welds on one rail sheared through the throat.

C-2—On the lip side, the welds on one rail sheared through the throat. On the head side, the plate broke at the bolt hole nearest the joint.

C-3—Both plates broke at the bolt hole nearest the joint.

Table 2—Results of Tensile Tests of Rail Joints Welded by the General Electric Company

Joint No.	Time, Min.	Welding Rod, Lb.	Tensile Strength, Lb.	Location of principal failure
Group A, butt welded, not rotated. Direct current, metallic arc, hand welding process.				
A-1	75	2.25	453,000	Weld
A-2	114	2.61	343,000	Weld
A-3	83	2.74	386,000	Weld and web of one rail
Group B, butt welded, rotated. Atomic hydrogen process.				
B-4	30	1.03	374,000	Weld
B-5	33	0.95	293,000	Weld
Group C, side plates welded on. Atomic hydrogen process.				
C-1	118	3.12	410,000	Plate and welds
C-2	144	3.87	464,000	Plate and welds
C-3	109	2.37	361,000	Plates

Repeated Impact Tests. Three specimens of each group were tested in the rail joint repeated impact testing machine. As in previous tests, the hammer weighed 400 lb. and in dropping 6 inches, struck the specimen at the middle of the 22-inch span. The hammer struck one of the rails 2 inches from the ends of the rails which were in contact at the joint. The approximate number of blows per minute was 88.

The results of the tests are given in Table 3, and failure charts are shown in Fig. 2. Fig. 3 is a photograph showing the broken ends of the specimens of group A, butt welded, not rotated, after failure in the repeated impact testing machine.

Table 3—Results of Repeated Impact Tests of Rail Joints Welded by the General Electric Company

Joint No.	Time, Min.	Welding Rod, Lb.	No. of Blows to Cause Failure	Location of Principal Failure
Group A, butt welded, not rotated. Direct current, metallic arc, hand welding process.				
A-4	78	2.81	114,600	Weld
A-5	65¼	1.92	79,800	Weld
A-6	82	2.16	9,600	Weld
Group B, butt welded, rotated. Atomic hydrogen process.				
B-1	32	0.73	72,200	Weld
B-2	29	0.81	18,500	Weld
B-3	35	0.69	49,000	Rail
Group C, side plates welded on. Atomic hydrogen process.				
C-4	88⅛	2.50	39,000	Plates and weld
C-5	99	2.69	42,100	Plates and weld
C-6	121	2.19	58,100	Plates and weld

Report of Shear Tests of Specimens Taken from Rail Joint Made by Atomic-Hydrogen Process

H. M. STEWARD*

THIS report includes the results of Shear Tests on a section of welded rail joint sent me by W. W. Wysor, Chief Engineer, United Railways and Electric Company, Baltimore, Md.

The specimen was taken from a rail joint made up of two pieces of 7-in. girder rail, A. E. R. E. A. standard with 24-in. rolled channel plates and canted base plate and was welded for the United Railways and Electric Company by the General Electric Company using the Atomic Hydrogen Arc Welding Process.

The section, 8 in. in length, was cut in two with a rail saw making two specimens of approximately 4 in. in length. The tests were conducted at Massachusetts Institute of Technology by Prof. H. W. Hayward in approximately the same manner as those reported by Prof.

Shear Tests of Specimen Cut from Rail Joint Welded by the Atomic-Hydrogen Arc Welding Process

Specimen	Location of Seam	Area, Sq. In.	Proportional Limit, Lb.	Proportional Limit, Lb. Sq. In.	Maximum Load, Lb.	Maximum Load, Lb. Sq. In.	Load at Scaling, Lb.	Gross Length of Weld, In.	Av. Width of Weld, In.
17	T-L	0.593	17,000	28,700	25,700	43,400	25,000	3.80	.156
	T-H	0.859	20,000	23,300	31,800	37,100	25,000	3.87	.222
	B-L	0.601	22,000	36,700	31,400	52,200	30,000	3.62	.166
	B-H	0.727	22,000	30,300	35,700	49,100	30,000	3.95	.184
18	T-L	1.04	22,000	21,100	38,800	37,400	30,000	3.63	.286
	T-H	0.706	10,000	14,100	19,700	27,900	15,000	3.60	.196
	B-L	0.893	22,500	25,200	40,000	44,800	32,500	3.60	.248
	B-H	1.07	12,000	11,200	23,200	21,800	20,000	3.55	.300

T-L means Top-Lip. B-L means Base-Lip.
T-H means Top-Head. B-H means Base-Head.

Fogg of Lehigh University and covered in Progress Report No. 5 of the Committee on Welded Rail Joints.

Tabulation of the results and prints of the load shear diagrams are attached.

An attempt was made to determine the load producing the first crack, but after several trials this observance was given up. Minute cracks

*Supt. of Maintenance, Boston Elevated Railway Co.

possibly occur fairly early and are obscured by the lime coating. No serious cracks were noted until after the maximum load was reached. The appearance of fractures was irregular and variable and it was deemed impossible to adequately describe them by the use of a single word as in Professor Fogg's report. In no case could a weld be described as very poor.

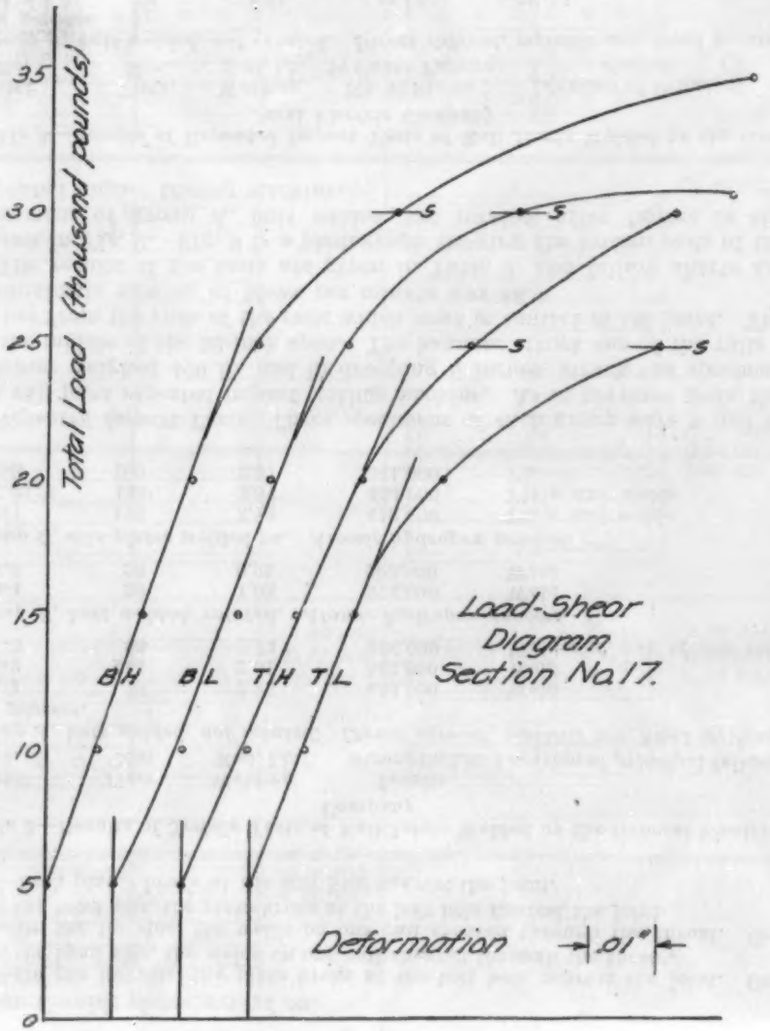


FIG. 1

but after several trials this observance was given up. Minute cracks

*Supt. of Maintenance, Boston Elevated Railway Co.

FIG. 1

Referring to the load shear plots, what is considered to be the best representative line is drawn for each specimen. The proportionate limit is taken as a load where the curve has definitely departed from the straight line. The load at which scaling as defined above took place is indicated on the graphs by the letter "S".

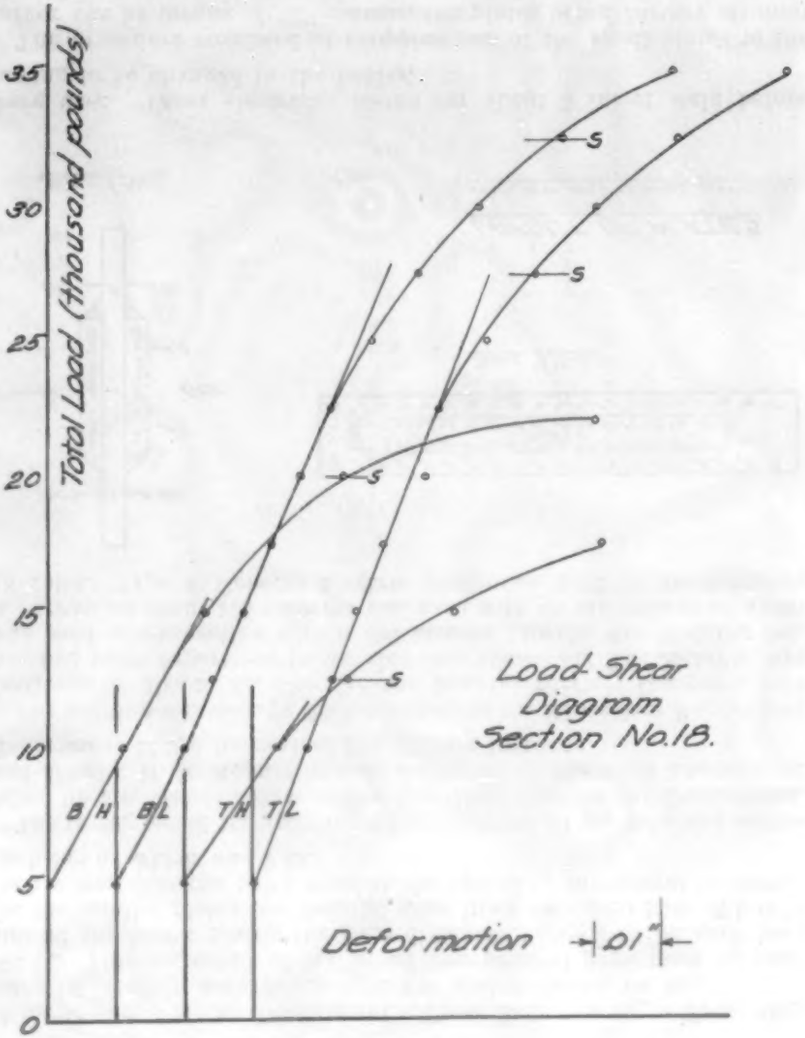


FIG. 2

Report of Investigation of Internal Stress Produced by Welding

T. R. LAWSON†

THE strength of welded rail joints has been under consideration by the Welded Rail Joint Committee of the American Electric Railway Association and the American Bureau of Welding for several years. Considerable experimental work has been carried out by the collaborating laboratories and much valuable information has been obtained and is available for those interested in this subject.

In carrying out these researches, some attention has been given to the heat effects of welding and there has been some discussions of both pre-heating and post-heating as an aid to the reduction of possible internal stresses due to welding.

That internal stress exists as a result of welding operations is beyond question, as a mere bead run along the edge of a plate will produce deformation in the plate easily measured by an extensometer and every operator of a welding outfit is aware of the distortion produced by running a bead along the side of a plate.

In order to investigate this as applied to welded rail joints, a combination of plates and rails were put together by means of seam or fillet welds approximating the condition of the tie plates on the side of a street rail. Two plates 3 in. wide by ½ in. thick of soft steel were used and were welded to the web cut from a 7-in. girder rail.

The girder section from which the webs were cut, were rolled under the A. E. R. E. A. specifications for Girder Rails, Class B. The chemical analysis was approximately as follows:

Carbon	.70 to .85
Manganese	.60 to .80
Silicon	.15 to .40
Phosphorus	Not over .04

The smaller plates had a chemical content of

Carbon	.10
Manganese	.36
Phosphorus	.009
Sulphur	.045
Silicon	.03

Both the wide and narrow plates were made of open hearth steel.

These plates were sent to the laboratories of the General Electric Company at Schenectady, where they were normalized at a temperature of 700 deg. C. under the direction of W. S. Warner of the Industrial

†Head of Dept. of Civil Engineering, Rensselaer Polytechnic Institute.

Heating and Welding Department. Upon their return to Troy, they were laid out in accordance with the sketch shown on the drawing No. 1. This consisted of laying off two parallel gage lines on each side of the larger plates, the gage distances being 2 in. on each line. On the smaller plates two parallel gage lines were also laid off but in such a way that the holes were at the apices of equilateral triangles, each leg of which was 2 in.

The laying out of the specimens and collection of the data was undertaken by Mr. Wendell Hess of the Electrical Engineering Department, and Messrs. H. R. Kepner and A. D. Taylor of the Civil Engineering Department of the Rensselaer Polytechnic Institute.

The welding was done in the laboratory of the Rensselaer Polytechnic Institute by Mr. R. W. Clark of the General Electric Company, who has had large experience in work of this character. The Metallic Arc was used in connection with a 300 ampere Lincoln Arc Welding Set. A current of about 175 amperes was used with an arc voltage of about 18 volts. Type F General Electric electrodes, 5/32 in. in diameter,

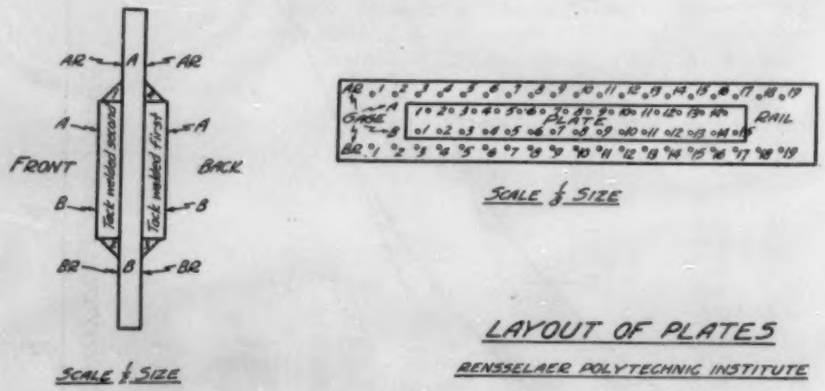


FIG. 1

were used. These electrodes lasted for about 3 in. of weld before having to be changed in the holder.

The procedure consisted of clamping one of the small plates to the larger one by means of "C" clamps, the plates being further clamped to a flat steel table in order to prevent deformation in the welding process in so far as it could be done. The small plates were then tack welded to the web of the rail by means of three or sometimes four small welds on each of the two long edges. The location of these tack welds is indicated by small rectangular areas on the accompanying drawings. After tack welding the small plate on one side of the web of the rail, the specimen was laid aside to cool and was not again touched until it had reached room temperature. This same procedure was followed throughout all of the welding processes and no welding was begun unless the plates were at room temperature.

The first set of readings was taken on the normalized plates before any welding was done and constituted the zero readings. All readings were taken with a 2-in. Berry strain gage with a dial reading to 1/10,000 of an inch. Since the lever ratio of this gage is 5 to 1, one division on the dial therefore will be a variation of 1/50,000 of an inch in 2 in. or 1/100,000 in. per inch. The accompanying curves indicate the results obtained on one of the three specimens that were welded. After each welding operation and the cooling of the plates to room temperature, extensometer measurements were made on all of the gage marks in the various lines and differences obtained between these readings and the zero readings. These are shown on sheets 2-1 to 2-8 inclusive. The various dotted lines indicate not only what operation has been performed but also the distortion produced by the operation. The letters AR and BR refer to the gage lines A and B on the rail, while the letters A and B refer to the gage lines on the small plates. The measurements on the back of the plate are given as though the observer is looking through the plate from the front.

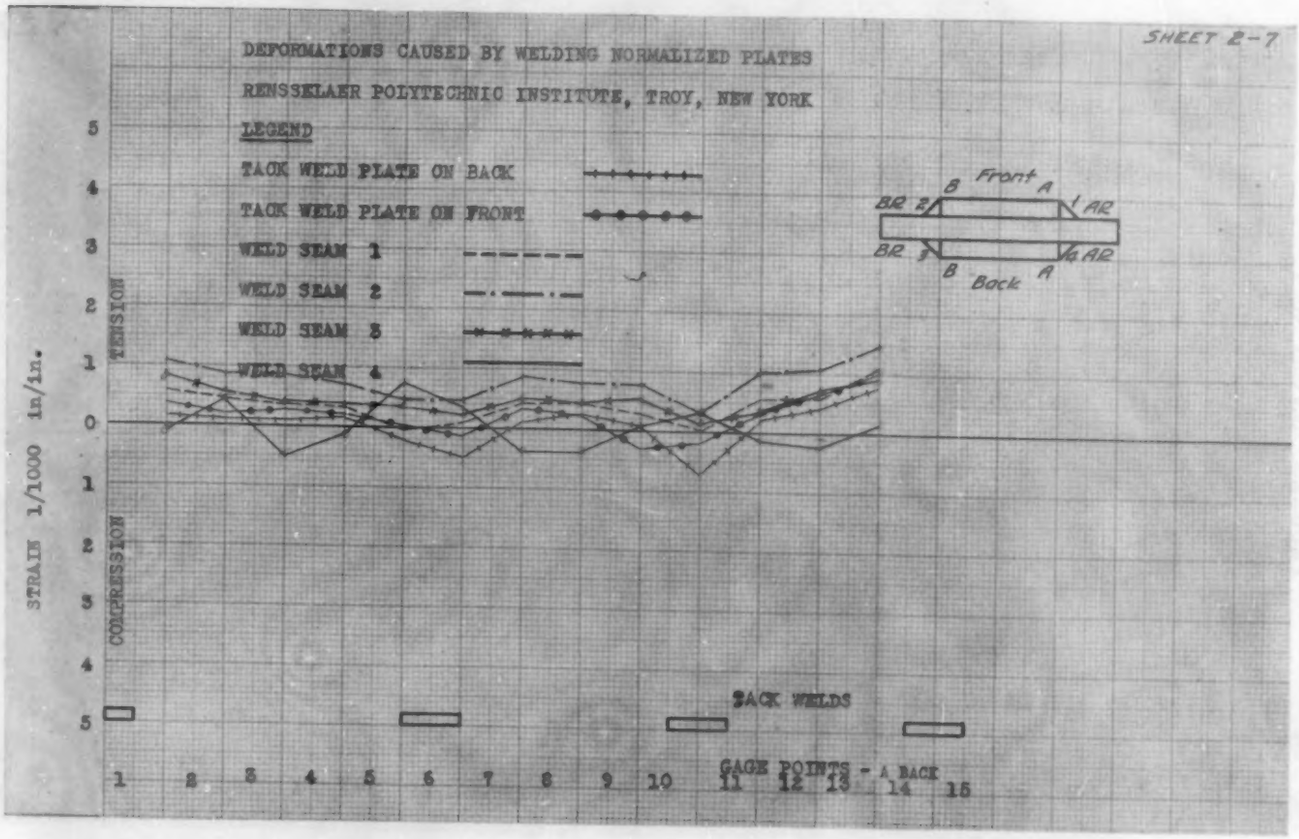
Observations during the welding and a study of the curves indicate.

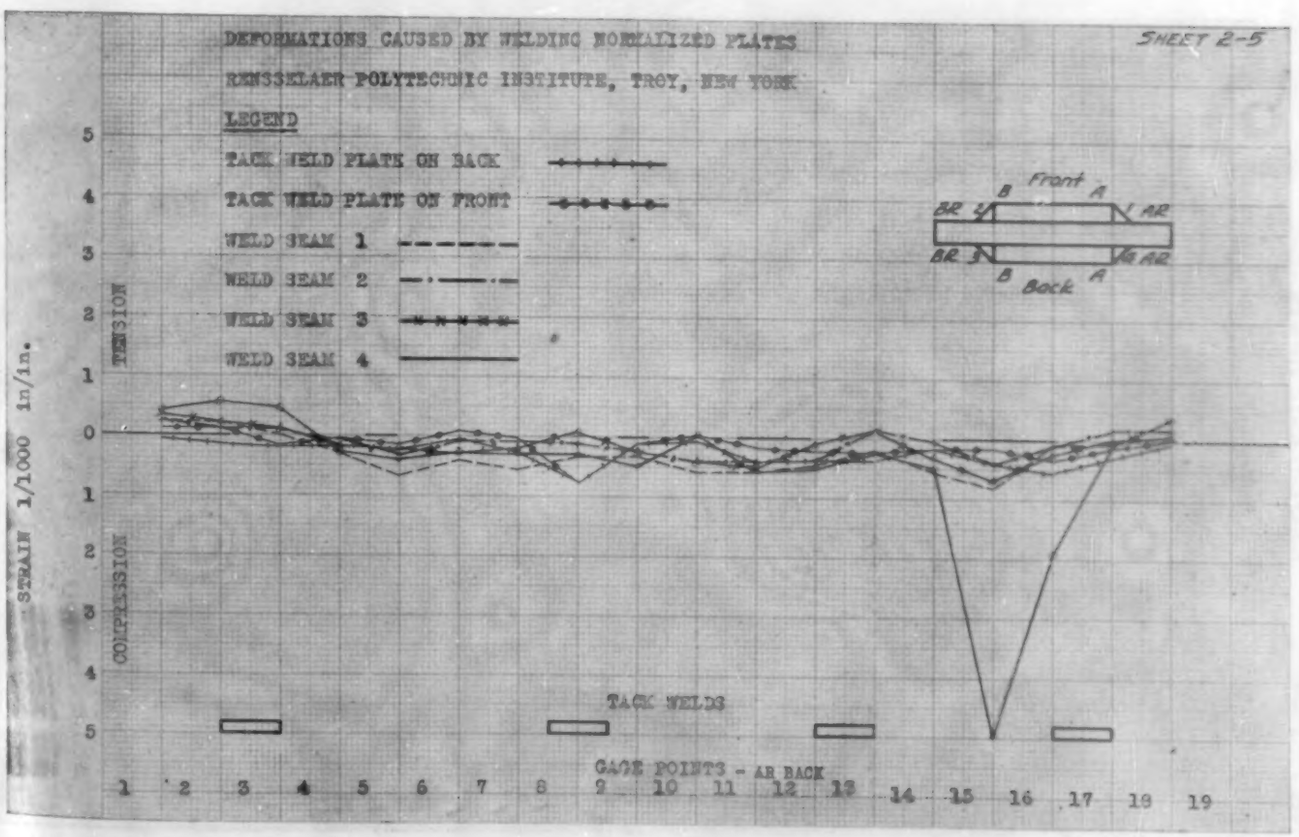
1. That after putting on the tack welds, the metal immediately under the tack welds was under compression while between the tack welds the material was in tension.
2. That the running of a fillet weld would sometimes cause the tack welds to break.
3. That with the running of the weld on one side, the material on that side would be in compression while on the opposite side it would be in tension.
4. That the first weld appears to fix the characteristic distortion for the gage marks nearest the weld for while this will be affected slightly by subsequent welds along the other edges, yet in general the effect of the first weld will not be entirely nullified.
5. That in the case of the small plates, for the most part it was shown that the effect of welding the edges produced tension in a diagonal direction.

The curves showing the observations given in No. 5 do not accompany this report.

As a result of the tests and a study of the curves, it is apparent that considerable deformation exists in the plates as the result of the welding operations. In order if possible to ascertain whether this is a permanent change caused by the welding operations and whether or not internal stresses produced remain in the plates, a second series of experiments was carried out on one of the specimens.

The specimens had been resting in the laboratory for approximately one year when a new set of gage readings were taken. On comparing these with the set that had been taken just after the welding operations were completed, it was noted that the two sets of readings did not agree. Inasmuch as the same instrument had been used in both cases, it was apparent that a change in length must have occurred during the interval of rest. The new set of readings were assumed as a zero and the welds were planed off in the reverse order from which they were put on, that is, the last weld was removed first. Extensometer readings were taken after each weld was removed and the specimen had reached room temperature. The difference be-

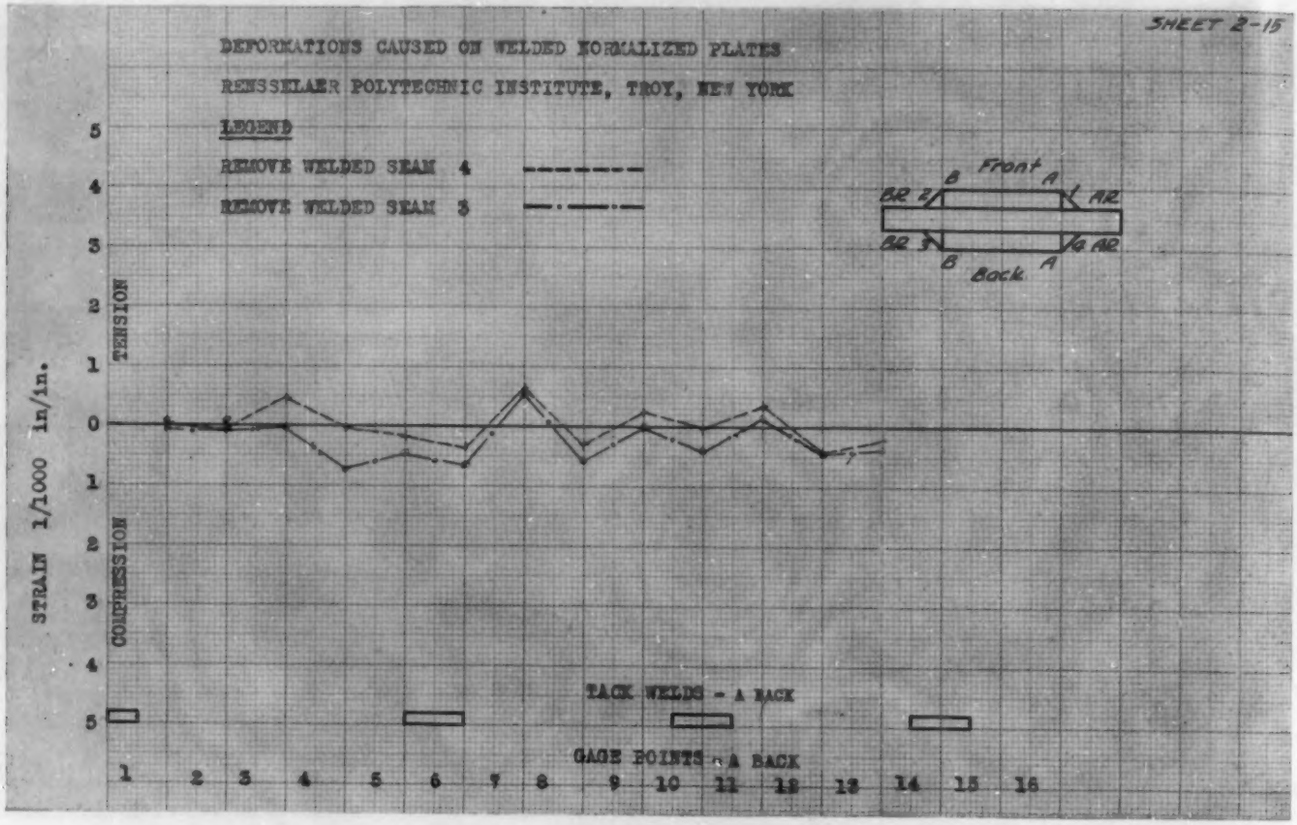




From which they were put on, that is, the last weld was removed first. Extensometer readings were taken after each weld was removed and the specimen had reached room temperature. The difference between which it had reached room temperature. This same procedure was followed throughout all of the welding processes and no welding was begun unless the plates were at room temperature.

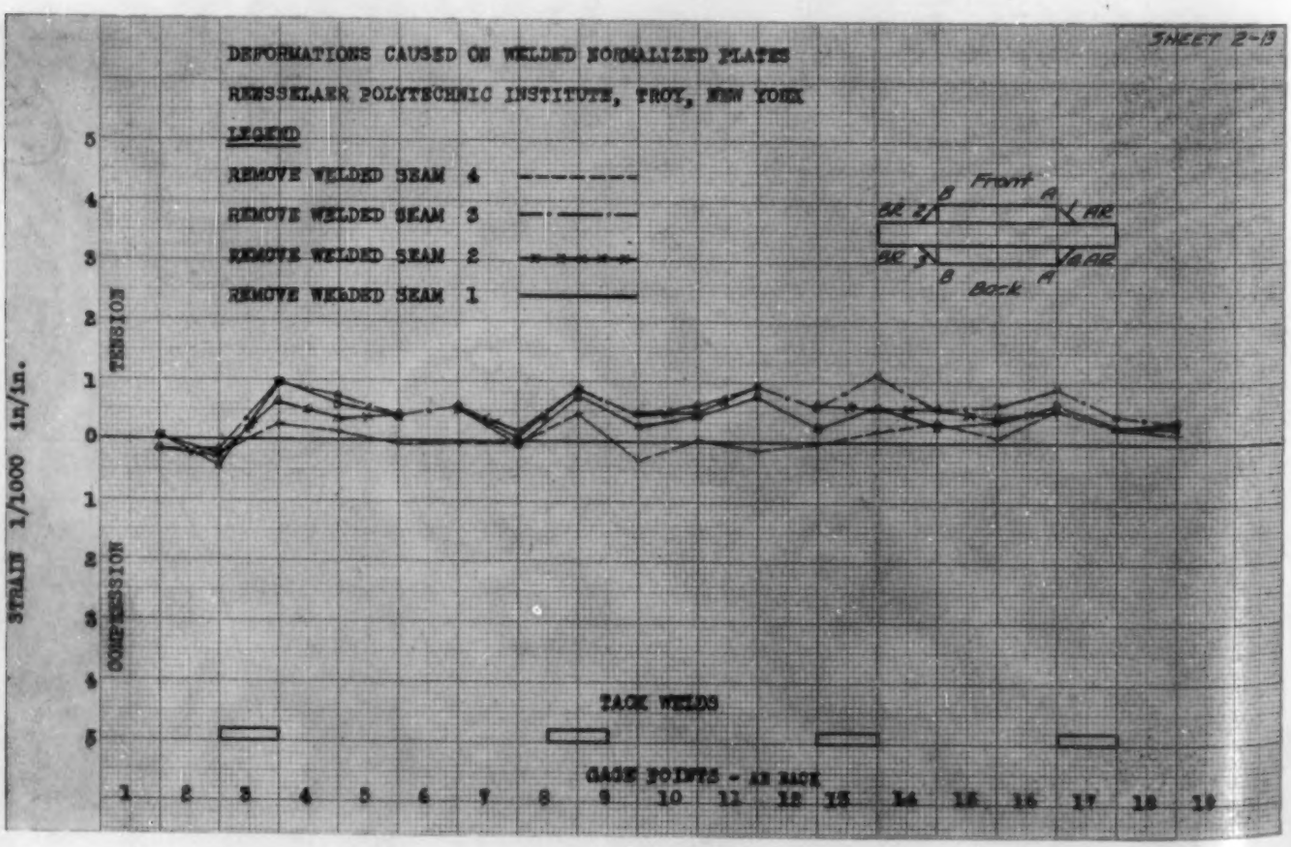
PROGRESS REPORT NO. 7

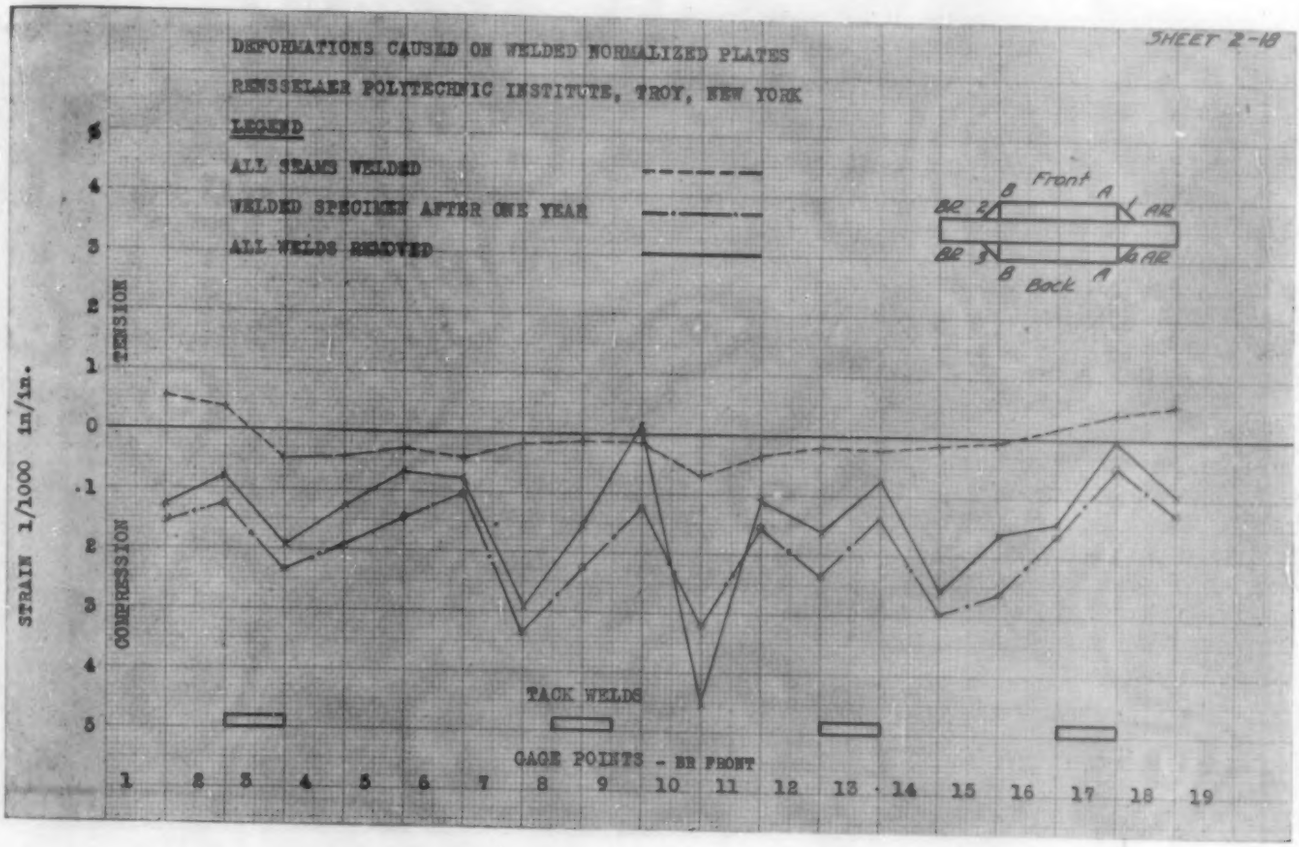
Page Fifty

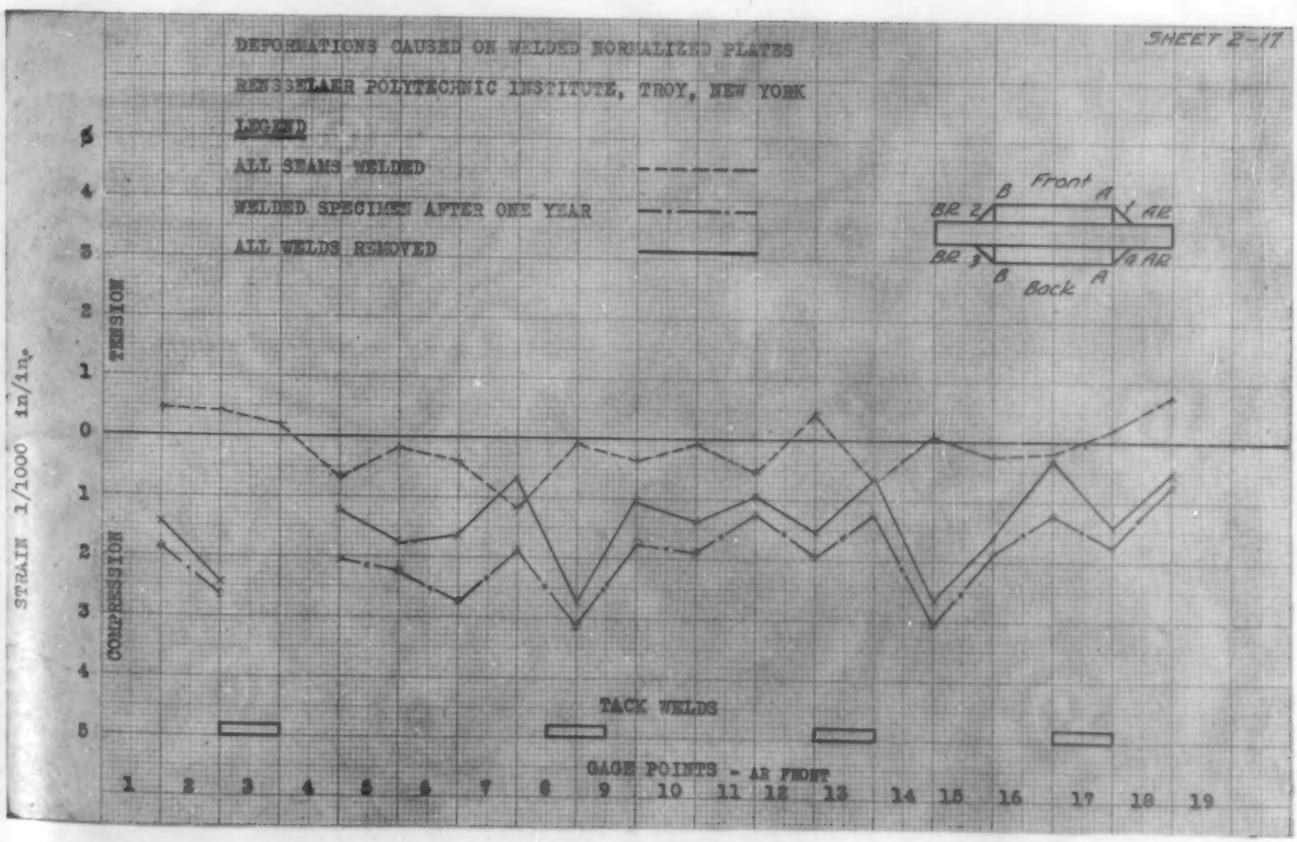


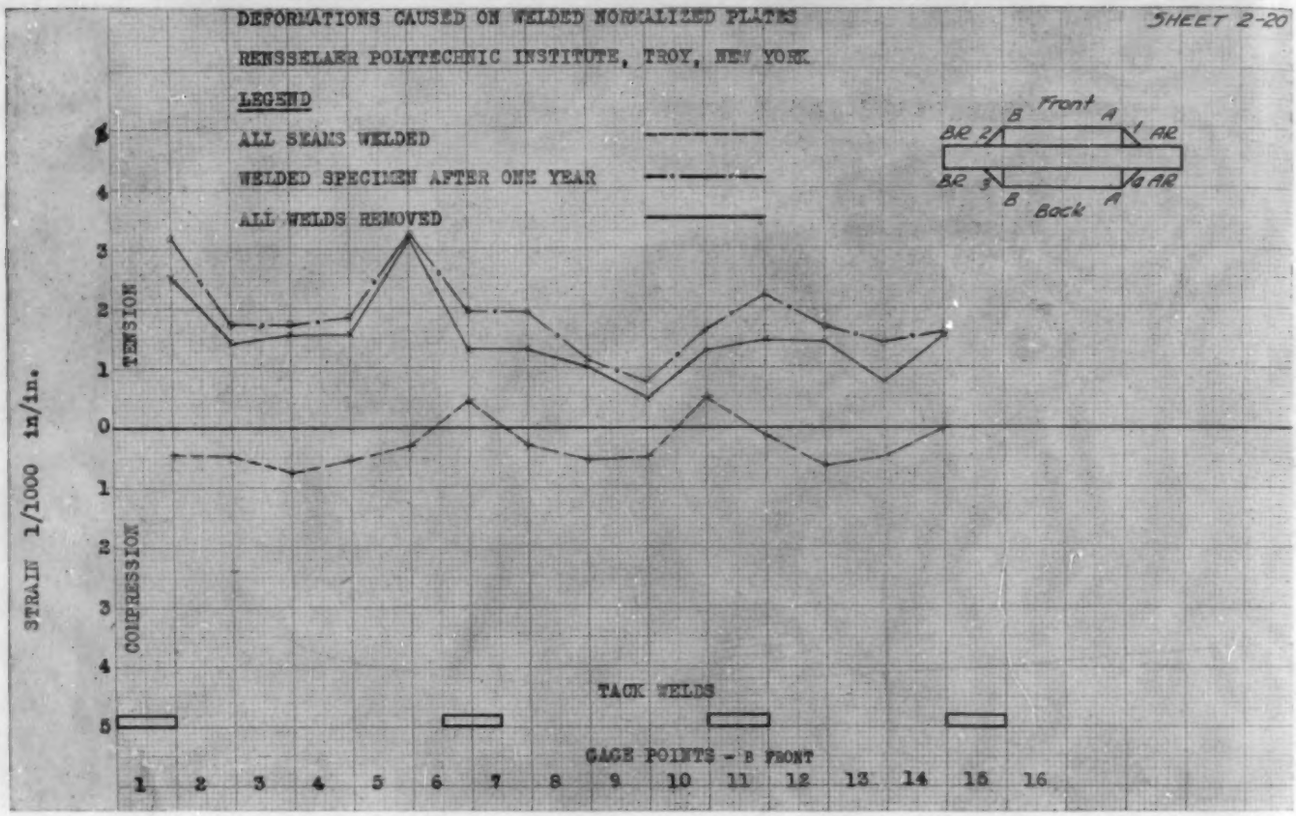
WELDED RAIL JOINTS

Page Forty-nine

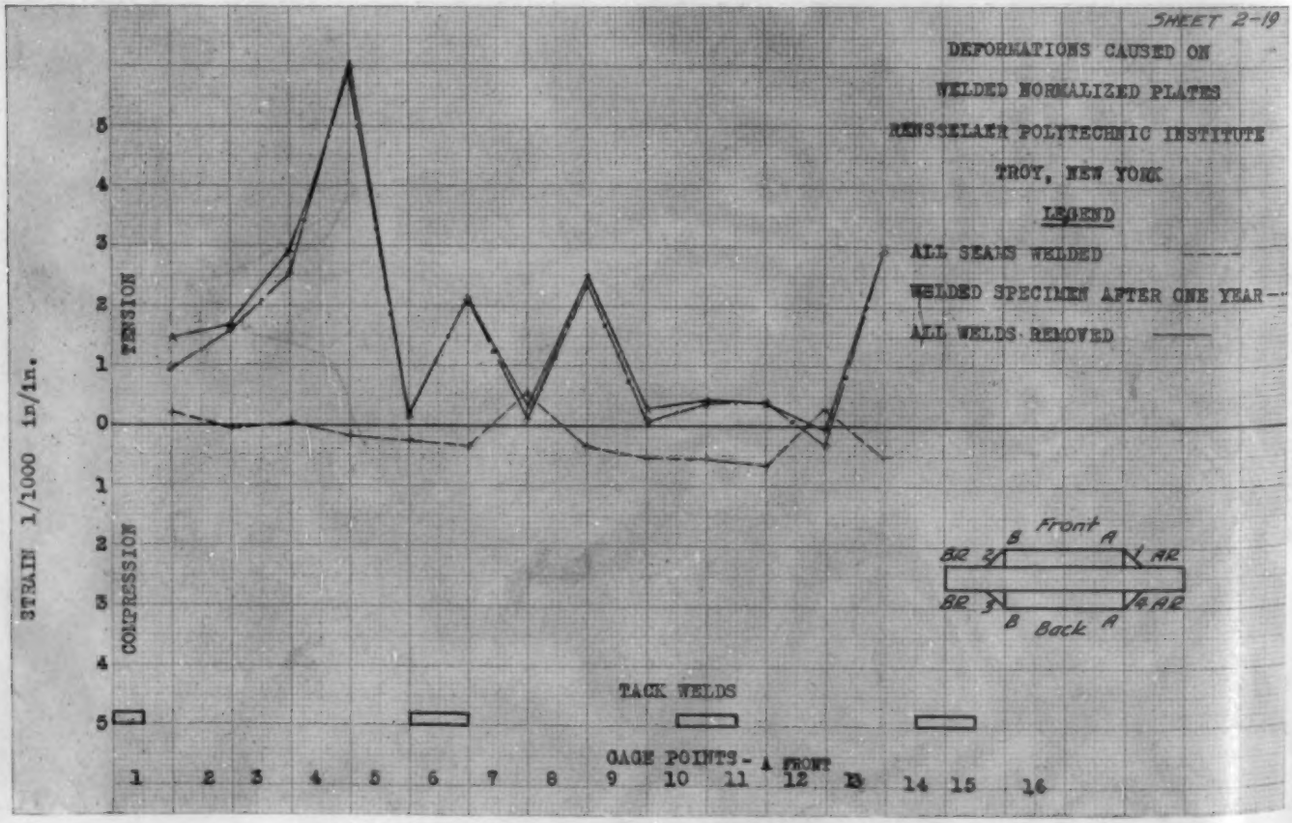



SHEET 2-18
DEFORMATIONS CAUSED ON WELDED NORMALIZED PLATES
RENSSELAER POLYTECHNIC INSTITUTE, TROY, NEW YORK
LEGEND
ALL SEAMS WELDED
WELDED SPECIMEN AFTER ONE YEAR
ALL WELDS REMOVED
Front
Back
BR 2
BR 3
AR
STRAIN 1/1000 in/in.
TENSION
COMPRESSION
TACK WELDS
GAGE POINTS - BR FRONT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

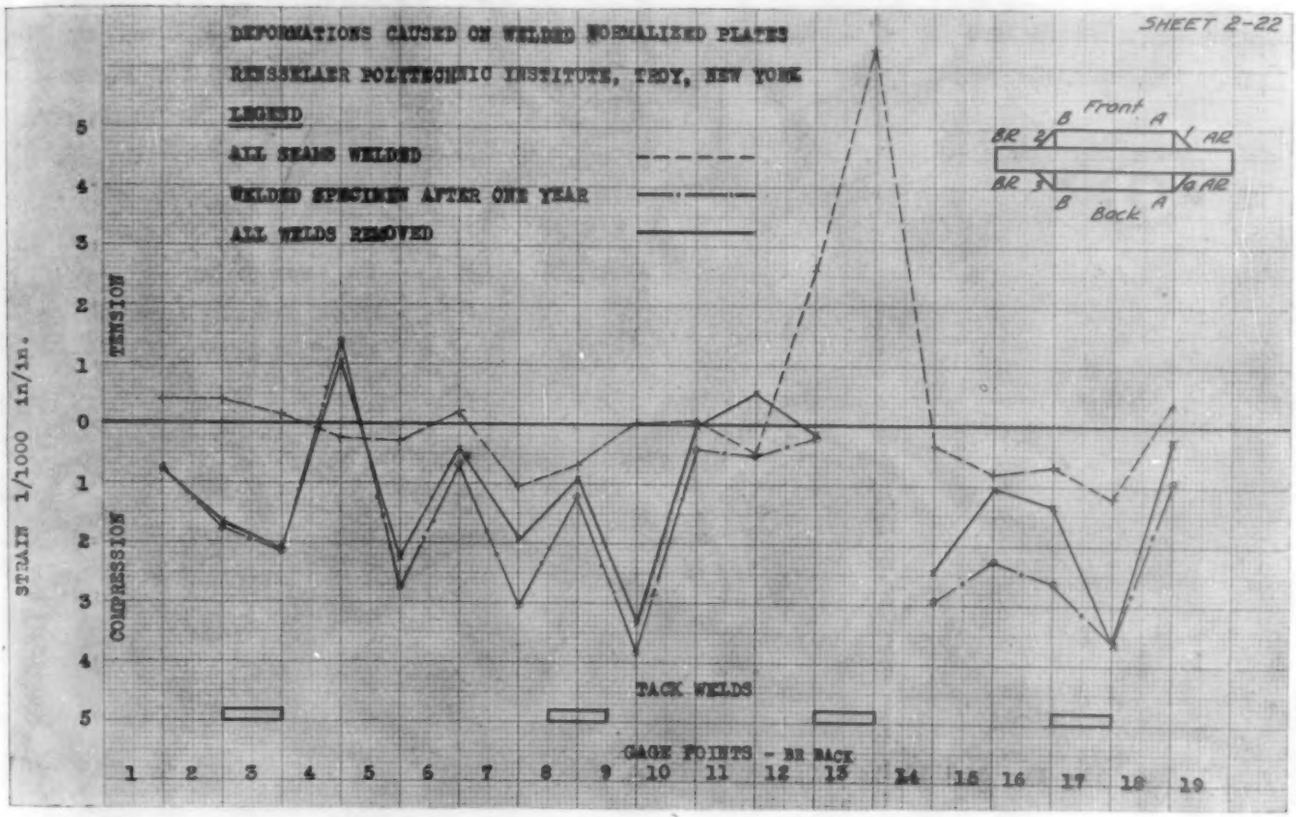

SHEET 2-17
DEFORMATIONS CAUSED ON WELDED NORMALIZED PLATES
RENSSELAER POLYTECHNIC INSTITUTE, TROY, NEW YORK
LEGEND
ALL SEAMS WELDED
WELDED SPECIMEN AFTER ONE YEAR
ALL WELDS REMOVED
Front
Back
BR 2
BR 3
AR
STRAIN 1/1000 in/in.
TENSION
COMPRESSION
TACK WELDS
GAGE POINTS - AR FRONT
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

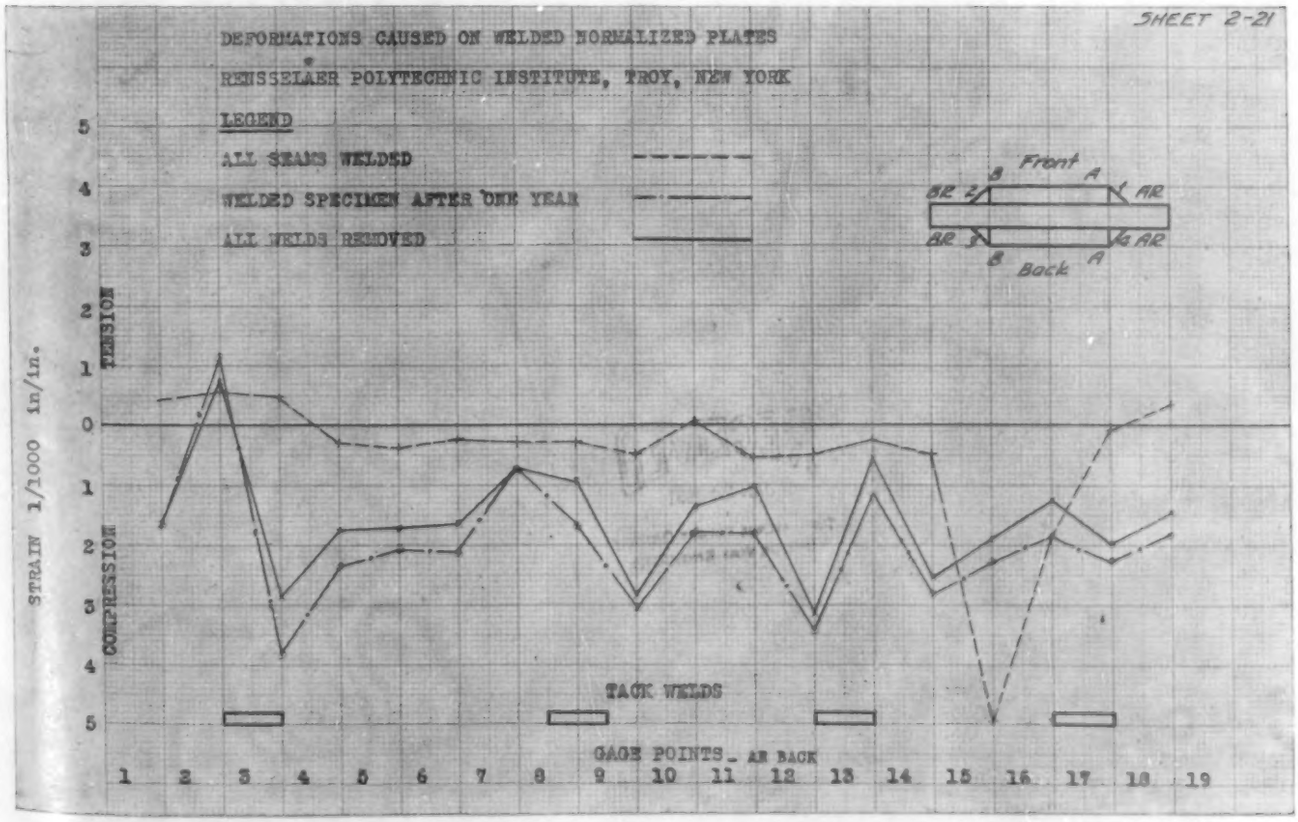


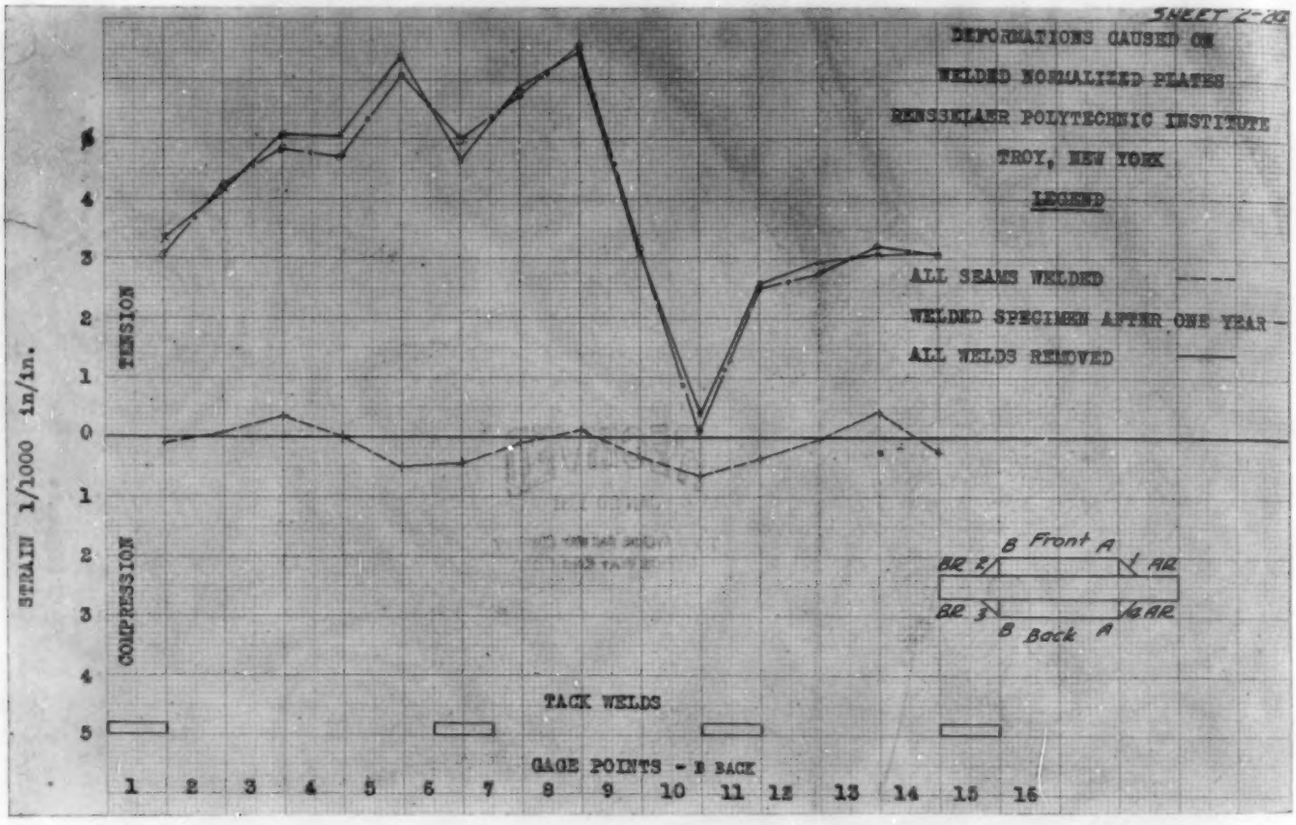
Page Fifty-four PROGRESS REPORT NO. 7



Page Fifty-three WELDED RAIL JOINTS

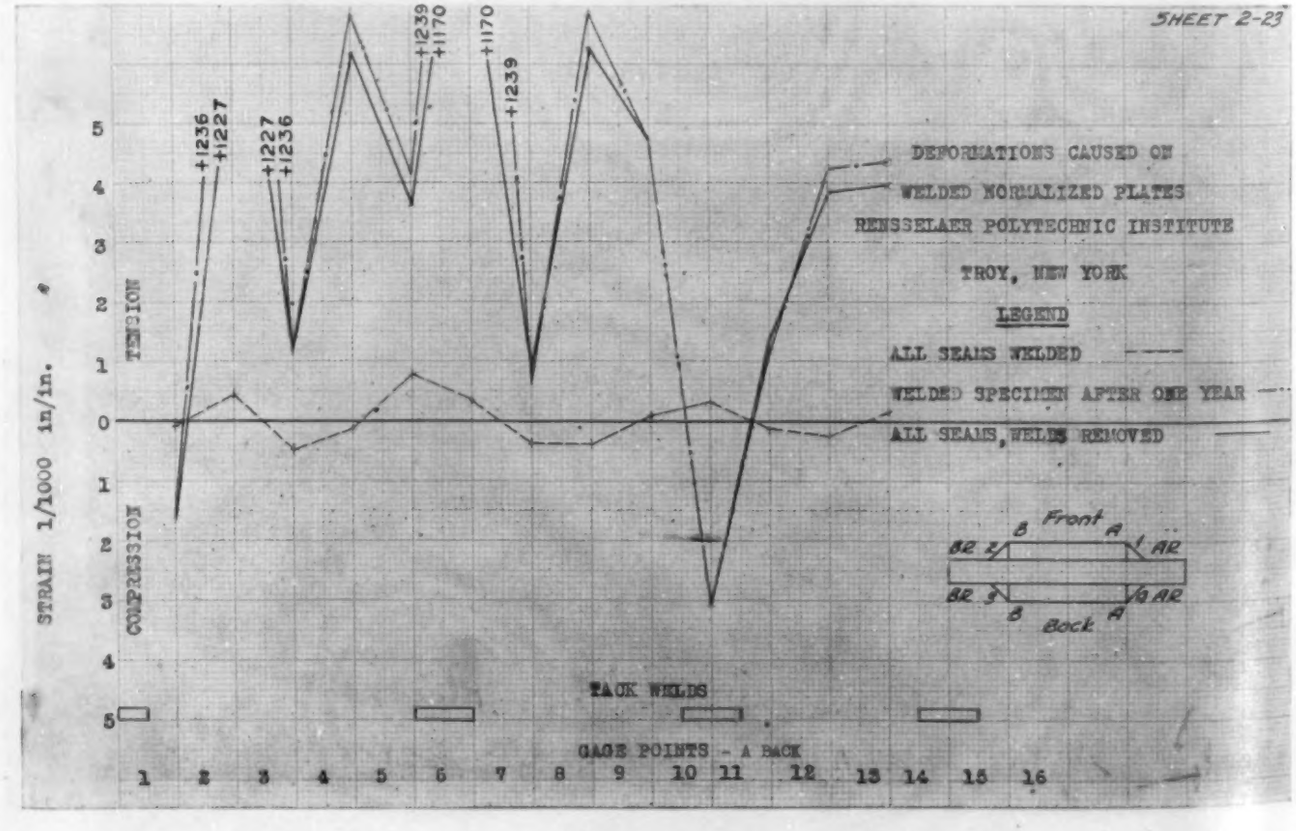

SHEET 2-22
DEFORMATIONS CAUSED ON WELDED NORMALIZED PLATES
RENSSELAER POLYTECHNIC INSTITUTE, TROY, NEW YORK
LEGEND
ALL SEAMS WELDED
WELDED SPECIMEN AFTER ONE YEAR
ALL WELDS REMOVED
Front
Back
BR 2
BR 3
AR
STRAIN 1/1000 in/in.
TENSION
COMPRESSION
TACK WELDS
GAGE POINTS - BR BACK


SHEET 2-21
DEFORMATIONS CAUSED ON WELDED NORMALIZED PLATES
RENSSELAER POLYTECHNIC INSTITUTE, TROY, NEW YORK
LEGEND
ALL SEAMS WELDED
WELDED SPECIMEN AFTER ONE YEAR
ALL WELDS REMOVED
Front
Back
BR 2
BR 3
AR
STRAIN 1/1000 in/in.
TENSION
COMPRESSION
TACK WELDS
GAGE POINTS - AR BACK



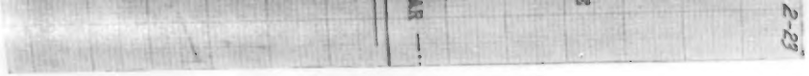
PROGRESS REPORT NO. 7

Page Fifty-eight



WELDED RAIL JOINTS

Page Fifty-seven



tween these readings and the new zero reading was then plotted on a new set of curves shown on sheets 2-9 to 2-16 inclusive.

A study of these curves indicates that as each seam is removed the tendency is, for the specimen to return toward its original unwelded condition, the most decided change being caused by the removal of the last weld, this last weld being the first seam weld that was put on the specimen.

A third series of curves were plotted, as shown on sheets 2-17 to 2-24 inclusive. These sheets indicate the changes that were made in the entire operation. The zero line is the original zero line of the unwelded specimen. The curve indicated by the series of dashes represents the deformation after the final welding operation, the measurements being taken immediately after the welding was completed. The long dash and dot line indicates the deformation in the specimen after one year's rest. The solid line indicates the final condition of the plate after all welds were removed.

A study of these results indicates that the effect of the rest or seasoning has been to cause compression in the web plates of the rail and tension on the small tie plates.

While these results are definitely indicated by the data from this specimen, it is felt that it should be confirmed by further experiments. With this in mind, additional extensometer measurements are being made on one other welded specimen which, as yet has had none of the welds removed. The work on this specimen is not yet complete but enough data has already been obtained to indicate the same tendency as in the first specimen.

Comments on Professor Lawson's Report "Stresses in Welded Joints"

W. SPRARAGEN

CURVES 2-1 to 2-16 (typical examples of which are reproduced) indicate that stresses of considerable magnitude are involved in the making of welded joints of the type used in street railway construction. At times, these stresses are beyond elastic limit of the material so that permanent distortions take place.

All of Curves 2-17 to 2-24 are reproduced. They indicate the changes that have taken place during the welding operation and after a year of aging and, finally, with the welds removed.

Important changes have taken place during the course of a year without anything having been done to the specimens during that period. Reports from the laboratory indicate that the difference in temperature at the time that gage readings were taken, and at the end of the year, were not very great.

Study of these curves indicates that the low carbon plate after a year was put in severe tension, in fact, the severity of the tension was such that permanent set took place. On the other hand, the high carbon plates were put in severe compression of a magnitude sufficient to cause permanent set. This is indicated by the fact that after the

*Secretary, Welded Rail Joint Committee.

welds were machined off the readings returned only a very small portion of the way toward normal, if the zero line is taken as conditions prevailing immediately after welding.

There is a consistency of readings which include tension in the low carbon plates and compression in the high carbon plates. These conditions did not exist in the gage readings which were taken directly after welding. If the gage readings at the edge of the low carbon plate are superimposed on the corresponding gage readings taken nearby on the high carbon plates, it is seen that where a severe compression is indicated in the high carbon plates a corresponding severe tension is indicated in the low carbon plates.

It was suggested that a change of structure had taken place during the interval of a year in the high carbon plates particularly and that change in structure involved a lengthening of the high carbon plates as compared with the low carbon plates. The rigidity of the welds were such that this movement was restricted until the stresses were large enough to cause permanent set.

Some of the discontinuities in the charts and extreme points may be explained by the fact that some of the tacks broke while the welding took place.

Dr. Zay Jeffries, in commenting upon this phenomena, stated:

"Although there may be some internal changes such as precipitation of iron carbide or iron nitride which will produce volume changes in the steels referred to in your letter, I am inclined to believe that the results which you describe can be explained by the initial stresses set up due to the melting and cooling and maintained for a long period of time. If the stresses were high enough to start a little slipping—that is, a very small amount of permanent deformation—the maintenance of these stresses for a year would be expected to produce the slight flow which you observed."

Commenting further on the results of his report Professor Lawson states:

"I am not at all satisfied that the deformations shown on the curves indicate stress as there may have been heat effects causing some of them. In addition to this you will note that most of the high points in the curves occur where the specimens were tack welded. During the process of welding, it was observed in some instances that the tack welds gave way when the specimens were being welded on the opposite side. One explanation, then, of some of these high points is the failure of tack welds.

"For the benefit of those who feel that these deformations represent stress, the stress per square inch can be obtained by multiplying the deformation as noted on the sheets by the modulus of elasticity 30,000,000, since the deformations shown are given in terms of strain in one-thousandths of an inch per inch.

"It would be well to remember that the readings given on the first sixteen sheets were taken immediately following the welding operations and there could have been but little chance for internal stress to occur from the seasoning effect which appears to be very pronounced in the curves on sheets seventeen to twenty-four inclusive."

Fabrication of Pipe Specials

(*Continued from page* 13)

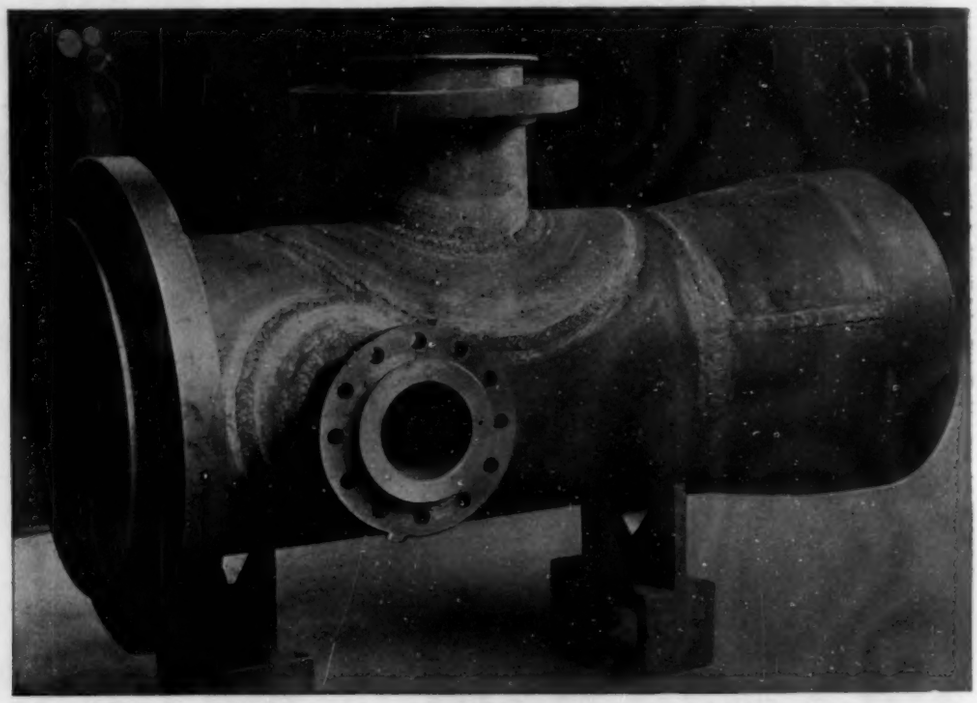
Two Van Stone nozzles were also welded to the 22-in. section. These were reinforced with a saddle plate welded on.

Many public utility companies make it a standard practice to fabricate all gas main specials by welding. The compactness of welded specials makes it possible to install them with a minimum of excavation, which is particularly important in emergency work. The flexibility of welded construction also simplifies the problem of making complicated connections.

A typical example occurred recently in a large eastern city. Due to a break in the mains, an emergency need arose for a special to connect four different lines that were on two levels. Two of these lines, which were of different size pipe, were at right angles to the other two lines. Furthermore, this hookup had to be placed 4 ft. under the street and in a space not greater than 5 x 10 ft. in area.

This special was quickly fabricated by welding in the yards of the gas company according to specifications, delivered to the excavation site, and welded into position.

Examples might be multiplied indefinitely but these brief descriptions together with the accompanying illustrations will serve to emphasize the variety of pipe specials that can be fabricated easily and economically by the oxy-acetylene process.



Pipe Special for Natural Gas Line Fabricated by Welding

Discussion of Papers

Papers to be presented at the Fall Meeting of the Society will be published in the September issue of the JOURNAL, which will be distributed to all members in advance of the meeting.

These papers have been selected with a great deal of care by the Meetings and Papers Committee and represent a diversified list of papers on timely subjects by authorities in the welding field.

Each member is expected to contribute to this meeting by written or oral discussion of these papers.

SECTION ACTIVITIES

PORTLAND

The Portland Section held its annual meeting on July 7, at which the following officers were elected for the coming year.

Chairman—George Dierking.
Vice-Chairman—F. V. Romig.
Treasurer—William P. Kellogg.
Secretary—G. B. Herington.

DETROIT—The following is a summary of the meetings held by the Detroit Section during the 1930-31 season.

Date	Program	Attendance
Dec. 18, 1930	1. Illustrated lecture on Pipe Installation in large buildings, by C. P. Phillips of Detroit. 2. Motion pictures on Welded Pipe. 3. "Welding and Fabrication of Industrial Piping in Russia," by Walter J. Thomas	75
Jan. 26, 1931	Discussion of American Welding Society's "Code for Fusion Welding and Gas Cutting," led by Joseph Matte, Jr.	100 guests 25 members
March 24, 1931	"25 Years of Electric Welding," by P. W. Fassler.	130 guests 20 members
April 28, 1931	Automatic and Semi-Automatic Arc Welding, by C. E. Swift	35

LOS ANGELES—The following is a summary of the meetings held by the Los Angeles Section during the 1931 season.

Date	Program	Attendance
Jan. 30, 1931	Motion Picture of all welded "Upper Carnegie Bldg.," in Cleveland, Ohio	60
Feb. 10, 1931	Discussion of metallurgy of welds with photomicrographs	50
March 17, 1931	Visit to Oil Equipment Exposition at Compton	30
April 14, 1931	Discussion of X-Ray examination of welds. Demonstration of arc welding torch	45
May 14, 1931	Discussion of world wide welding activities, by Major James Caldwell	40
June 16, 1931	Discussion of new A.S.M.E. Boiler Code as applied to welded unfired pressure vessels	45
	Total attendance for year	270